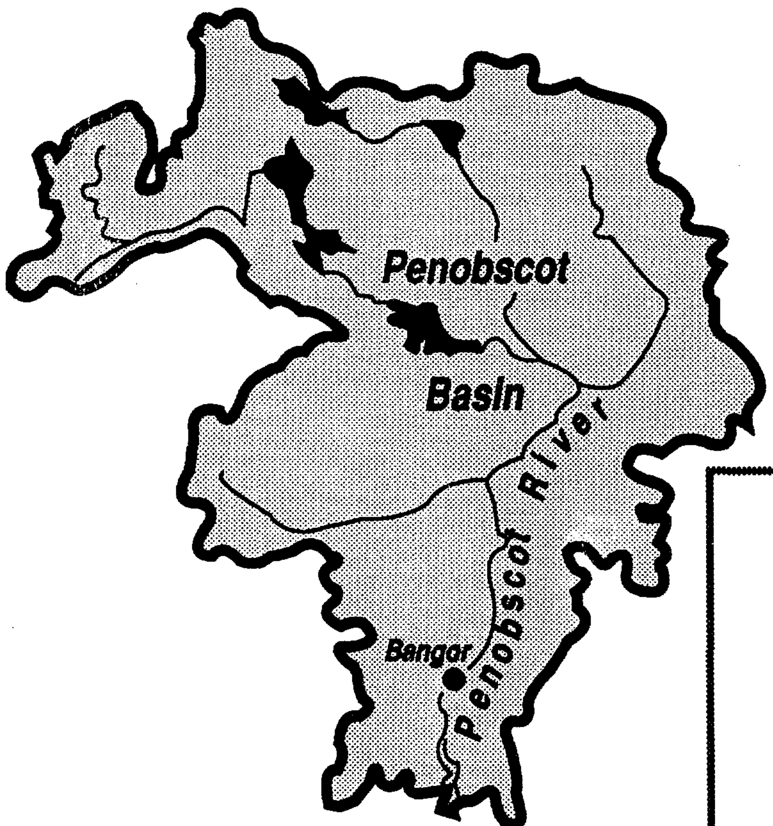
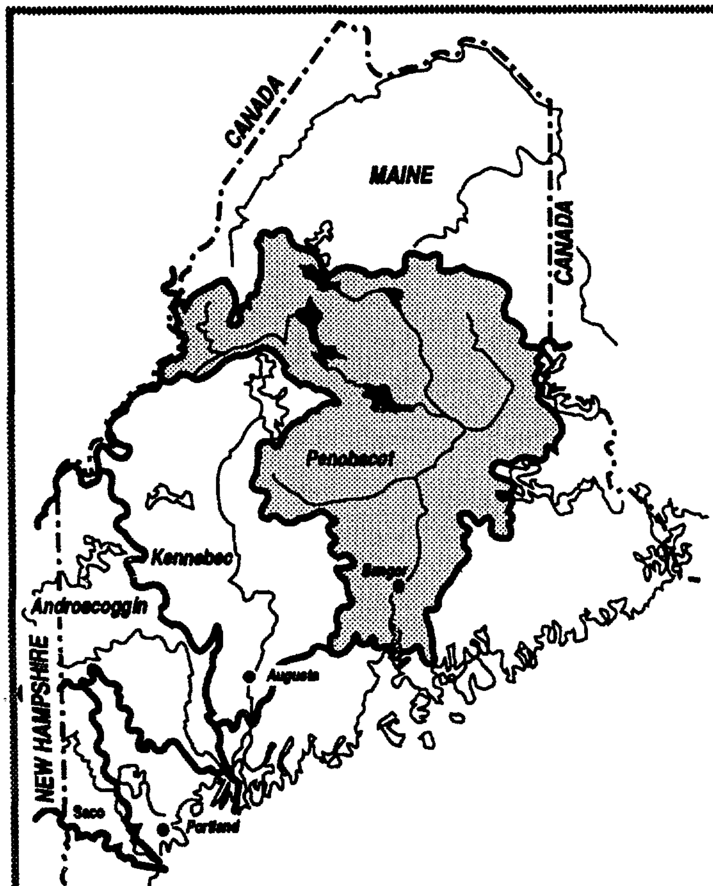
Water Resources Study

Penobscot River Basin
Maine

Penobscot River Basin Study





Penobscot River Basin Location Map

April 1990

US Army Corps of Engineers
New England Division

WATER RESOURCES STUDY

PENOBSCOT RIVER BASIN
MAINE

APRIL 1990

Department of the Army
New England Division, Corps of Engineers
424 Trapelo Road
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EXECUTIVE SUMMARY

This investigation was authorized by a Resolution of the Senate Committee on the Environment and Public Works, adopted May 5, 1987. The report documents the results of studies of the Penobscot River Basin to determine the advisability of improvements in the interest of flood control, allied purposes and related land resources. In coordination with the study sponsor, the State of Maine, flood damage reduction was considered to be the primary goal of the study with other needs addressed only as part of any justified flood control improvements.

The Penobscot River Basin has a total drainage area of approximately 8,570 square miles. It is the largest river basin lying totally within the State of Maine, and the second largest in New England, being exceeded only by that of the Connecticut River. The basin covers approximately one quarter of the State, has a maximum length in a north-south direction of 125 miles and a maximum width of about 115 miles.

The history of floods in the Penobscot River Basin goes back nearly 150 years, but reliable information on the magnitude of floods was not generally available until 1901 when the U.S. Geological Survey established a gage at West Enfield. Major floods in the Penobscot Basin are caused principally by a combination of heavy rainfall and melting snow in the spring of the year. The four greatest known floods; April/May 1923, March 1936, April/May 1973 and March/April 1987, were the result of these factors. The April/May 1923 flood is the flood of record on the Penobscot River and the March/April 1987 flood is the record flood in the Piscataquis River sub-basin. Flood related losses for communities in the basin for the 1987 event were estimated by the State at $9.1 million.

Due to the size of the basin and number of communities along its rivers, an initial screening process was utilized to focus investigation on areas with a high potential for flood damage. Numerous meetings were held with state, community, and other officials to identify specific areas that either experienced severe flooding during 1987 or have a high potential for future flooding. Based on this screening process, a total of 13 communities were selected for analysis. Total damages in these communities account for more than 90 percent of the damages reported in the basin during the March/April 1987 flood. The communities selected for analysis are listed below.

Abbot	Old Town
Guilford	Orono
Dover-Foxcroft	Bradley
Milo	Eddington
Howland	Brewer
Passadumkeag	Bangor
Milford	

Flood damage reduction measures formulated and evaluated to prevent or reduce damages in the communities included upstream reservoirs, structural and nonstructural local protection projects and an automated flood warning and evacuation system for the basin. Structural local protection measures evaluated consisted primarily of earth dikes and concrete floodwalls. Nonstructural floodproofing measures included raising or installing flood shields on certain flood prone structures. The automated flood warning system consists of a series of gages which collect data concerning rainfall, streamflow and lake levels. This information is reported to centralized computer stations which estimate the time and severity of flooding.

Investigation of these measures determined that flood forecasting and warning is the only economically justified flood damage reduction measure. The total estimated first cost of this automated system is $612,000 and the benefit to cost ratio is 1.32. This alternative is supported by the non-Federal sponsor, the State of Maine.

The results of the study indicated that further study of the automated flood warning system could be accomplished under the existing Continuing Authorities Program which does not require specific Congressional action. It is therefore recommended that no further work be conducted in the Penobscot River Basin under The General Investigation Study Authority.

WATER RESOURCES STUDY
PENOBSCOT RIVER BASIN MAINE

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SECTION I

INTRODUCTION

The severe flooding of April 1987 rekindled efforts of Federal, State and local officials to seek out methods of preventing a recurrence of such widespread damage. As a result of their efforts, the United States Senate Committee on the Environment and Public Works resolved that the Penobscot River Basin be reviewed to determine the advisability of improvements in the interest of flood control and allied purposes. This reconnaissance study evaluates these problems and reports on the feasibility of Federal assistance in implementing flood damage reduction measures.

STUDY AUTHORITY

This study was authorized by a resolution of the Senate Committee on Environment and Public Works, adopted May 5, 1987, which states:

> "Resolved by the Committee On Environment And Public Works Of The United States Senate, that the Board of Engineers for Rivers and Harbors, created under Section 3 of the Rivers and Harbors Act, approved June 12, 1902, be, and is hereby requested to review the Report on Land and Water Resources of the New England--New York Region printed in Senate Document Numbered 14, 85th Congress, First Session, with particular reference to the Saco River, Kennebec River, and the Penobscot River and their tributaries, Maine, with a view to determining the advisability of improvements in the interest of flood control, allied purposes and related land resources."

PURPOSE AND SCOPE

The purpose of this study was to identify flood control and related problems and opportunities within the Penobscot River Basin. Potential structural and non-structural improvements were evaluated based upon their benefits and costs, potential impacts on environmental and historic resources, and views of interested local officials. The results of this analysis were then used to establish the desirability of further Federal assistance in solving identified problems.

STUDY AREA

The Penobscot River basin, shown on Plate 1, has a total drainage area of about 8,570 square miles. It is the largest river basin lying totally within the State of Maine, and the second largest in New England, being exceeded only by that of the Connecticut River. The basin covers approximately one quarter of the State, has a maximum length in a north-south direction of 125 miles and a maximum width of about 115 miles. The majority of the basin is located in the upland region, with moderate to gentle slopes interspersed with occasional mountains. A principal feature of the central part of the basin is 5267 foot Mt. Katadin, the State's highest peak. This peak is situated in Baxter State Park, the largest recreation area in the State.

The basin is predominately rural, with a permanent population of about 165,000 (1980 census). Although the basin covers about 25 percent of the State, it contains only 15 percent of the population and has an average density of 19 people per square miles. Over half of the minor civil divisions that make up the basin are unpopulated. These are located primarily in the upper basin, which is largely undeveloped and has been owned by private timber interests since the 1850's. Much of the historic development in the basin was situated to support paper, lumber and related industries, with the economy of the central and northern basin continuing to depend heavily on forest resources. The economy of southern portions of the basin, such as the Bangor-Brewer area, is more diversified. Bangor, the largest city in the basin (30,010 people in 1980), serves as a regional employment and service center.

PRIOR STUDIES

NENYIAC REPORT - A report by the New England - New York Inter-Agency Committee, (NENYIAC), was completed in March 1955. It contains a comprehensive study of overall water resource problems and opportunities in the Penobscot River Basin and identifies potential management plans.

Penobscot River Basin Overview - This report was published by the New England River Basins Commission in September 1981. Through its evaluation of the basin's water and related land resources, it provides general guidance on the future use of these resources.

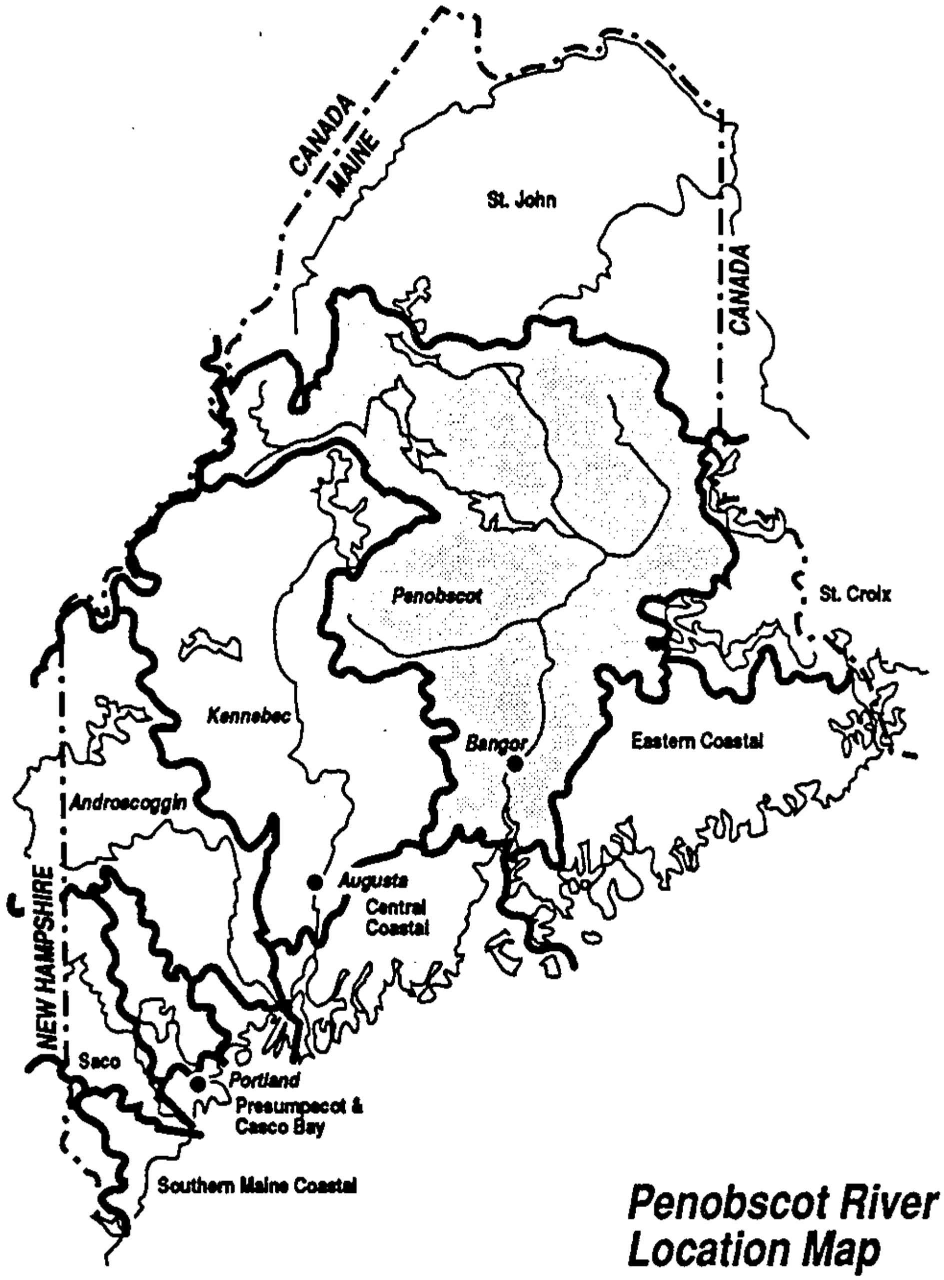
FLOODING ASSESSMENT AND DAMAGE POTENTIAL REPORTS, BREWER LAKE, Penobscot and Waldo Counties, and SEBEC LAKE, Piscataquis County, MAINE - These reports, completed by the U.S. Army Corps of Engineers in December 1986, evaluated present and future flood problems at these two lakes and made several recommendations for floodplain management.

FLOOD INSURANCE STUDIES - Flood insurance studies have been prepared by the Federal Emergency Management Agency for many communities in the Penobscot River Basin.

STATE OF MAINE 1988 WATER QUALITY ASSESSMENT - This report was prepared by the Maine Department of Environmental Protection, Bureau of Water Quality Control. This biennial report to the U.S. Environmental Protection Agency describes the quality of Maine's navigable waters.

ONGOING STUDIES AND INVESTIGATIONS

The U.S. Department of Agriculture, Soil Conservation Service, is currently investigating the flood problems in the upper Piscataquis River watershed. A reassessment of this area was requested by the Piscataquis County Soil and Water Conservation District shortly after the April 1987 flood which caused record flooding in this area. To date, several structural alternatives have been investigated, and it appears that at least one structural alternative, an upstream impoundment, shows potential for economic justification. The Soil Conservation Services is in the process of requesting authorization to conduct detailed planning studies, which will include an investigation of the full range of potential solutions.



Penobscot River Basin Location Map

Plate 1

REPORT AND STUDY PROCESS

This reconnaissance study is the first phase of a two phase planning process. This process provides a mechanism to accommodate significant non-Federal participation in Corps feasibility studies. The reconnaissance phase provides a preliminary indication of the potential of the study to yield solutions which could be recommended to the Congress as Federal projects. The results of the reconnaissance study provide the basis for decision-making within and outside the Corps and the Administration to evaluate the merits of continuing the study and allocating feasibility (second) phase funds. This reconnaissance phase has accomplished the following:

a. Defined the water and related land resources problems and opportunities of the study area.

b. Developed the objectives and constraints of the study based on identified needs and opportunities.

c. Identified measures to address these needs and opportunities.

d. Developed alternative plans to meet specific problems and opportunities.

e. Conducted a preliminary evaluation and screening of alternative plans, to include a preliminary determination of likely impacts and non-Federal views and preferences.

f. Described and discussed the likely array of alternatives to be carried into the feasibility phase, and identified a solution that is feasible and implementable.

g. Assessed the level of interest in and support for identified potential solutions, and obtained concurrence from the non-Federal sponsor of their understanding of cost sharing requirements.

h. Determined and recommended what additional planning should be undertaken, based on a preliminary appraisal of the Federal and non-Federal interest. This appraisal considered costs, benefits, impacts and support for the identified potential solutions.

i. For areas where further study is in the Federal interest, it recommends and initiates development of a Feasibility Cost Sharing Agreement to conduct more detailed studies in partnership with the non-Federal sponsor.

The planning process followed during each stage incorporates the four basic planning functions: problem identification, formulation of alternatives, impact assessment and evaluation.

Problem Identification - This task served to identify the flooding problems to be addressed and to establish study planning objectives. This included the development of a regional profile of environmental, social and economic conditions for the study area. The study objectives guided formulation of alternatives, whereas the regional profile served as a base condition for determining impact assessment and evaluating capabilities of alternatives.

Formulation of Alternatives - This process developed alternative flood plain management systems which responded to identified problems, concerns and the study area planning objectives. All potential measures available for problem solution were identified, and both structural and nonstructural measures were considered in developed plans.

Impact Assessment - This function included tasks required to determine the effect of each alternative plan on existing social, economic and environmental conditions. These effects were measured over the impact zone.

Evaluation - The evaluation function involved work tasks needed to measure and compare the relative values of each alternative plan, particularly in response to achieving the study objectives. Benefits and losses associated with the development of each plan were described in order to effectively analyze possible trade-offs between plans and to recommend further study or action.

SECTION II

PROBLEM IDENTIFICATION

EXISTING STUDY AREA CONDITIONS AND NATURAL RESOURCES

Basin Description - The Penobscot River, with a total watershed area of 8,570 square miles, is formed by the junction of its East and West Branches at Medway and follows a general southerly course to tidewater at Bangor, a distance of 74 miles. It then continues 31 miles further to its mouth at Turner (Steele) Point at the head of Penobscot Bay. In its 74-mile course between Medway and tidewater at Bangor, the river falls a total of about 240 feet at a fairly uniform slope averaging 3.2 feet per mile. Approximately 124 feet of this total fall are presently utilized by six hydropower developments on the river. The river has six sizable sub-watersheds or tributaries; the East and West Branch Penobscot Rivers (considered to be headwater tributaries), the Mattawamkeag River, the Piscataquis River, the Passadumkeag River and Kenduskeag Stream. A map of the basin is shown on Plate 2.

The East Branch Penobscot originates in the western and northernmost part of the basin. In this area several small streams that unite to form Allagash Stream which flows easterly 19 miles, through Allagash Lake, to Chamberlain Lake. The flow then continues in an easterly direction for 38 miles from Chamberlain Lake through a series of lakes and ponds to First Grand Lake. From the outlet of first grand lake, the East Branch flows in a general southerly direction for 47 miles to its junction with the West Branch at Medway. The drainage area of the East Branch is 1,100 square miles, including the 240-square mile watershed of Chamberlain Lake. This watershed was diverted from the Allagash River (originally part of the St. John River basin) to the East Branch by the Telos Canal. The total fall between Allagash Lake and the Penobscot River at Medway, a distance of 92 miles, is 805 feet. The East Branch proper, below Grand Lake, falls at an average slope of 8.8 feet per mile or a total of 414 feet in 47 miles. The greatest fall in this reach occurs seven miles below the outlet of Grand Lake where there is a drop of 130 feet in 2.5 miles, or more than 50 feet per mile. The total fall on Webster Brook, between Webster Lake and Grand Lake, is 244 feet in 8.5 miles.

The West Branch Penobscot River has its source in Seboomook Lake which is fed by a number of streams originating near the international boundary at the northwestern limit of the basin. From the outlets of Seboomook Lake, the West Branch follows a general easterly course for 97 miles through a series of lakes to its confluence with the East Branch at Medway. The West Branch has a drainage area of 2,100 square miles and a total fall, below Seboomook Lake, of 830 feet. The maximum slope in this branch occurs in the 17-mile reach below Ripogenus Lake where there is a fall of 445 feet. The steepest part of this fall occurs immediately below the dam at the outlet of Ripogenus Lake where the river drops 275 feet in 2.5 miles, or 110 feet per mile. The power facilities installed at Ripogenus Dam use 184 feet of this 275-foot fall. In the lower 15.5 miles of the West Branch, there is a fall of 255 feet, of which 230 feet have been developed by existing power or storage projects.

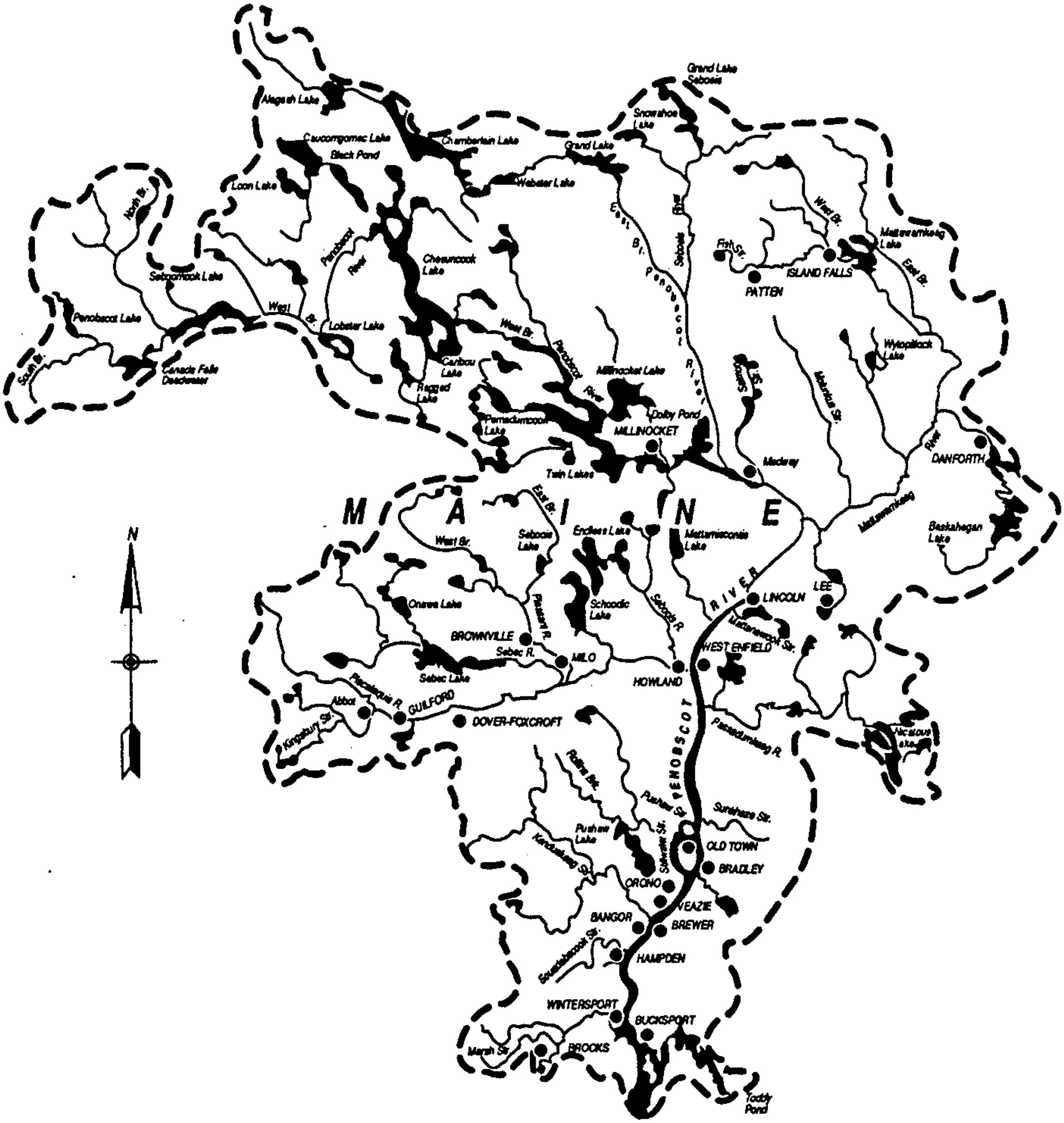
The Mattawamkeag River is formed by the confluence of its East and West Branches in the town of Haynesville. From this point, the river follows a general southwesterly course for 48 miles to its confluence with the Penobscot River at Mattawamkeag, 12 miles below Medway. It has a drainage area of 1,490 square miles. The total fall in this tributary below the outlet of Pleasant and Mud Lakes, in the headwaters of the West Branch, is approximately 630 feet in 91 miles. The maximum slope occurs immediately below Mud Lake where there is a drop of 150 feet in 2.5 miles.

The Piscataquis River rises on the southerly slope of little Squaw Mountain, about four miles southwest of Moosehead Lake (part of the adjoining Kennebec River Basin). From this point it flows southeasterly 27 miles to Guilford, where it turns and flows in a general easterly direction for 49 miles to its mouth on the Penobscot River in Howland. It has a drainage area of 1,454 square miles. The total fall in this tributary is approximately 1,400 feet of which 1,030 feet are in its upper 18 miles. In its lower 58 miles, the river drops approximately 370 feet at an average slope of 6.4 feet per mile. Two major tributaries of the Piscataquis River are the Sebec and Pleasant Rivers. The Sebec River joins the Piscataquis River in Milo, and the Pleasant River enters the Piscataquis River near the Milo-Medford town line.

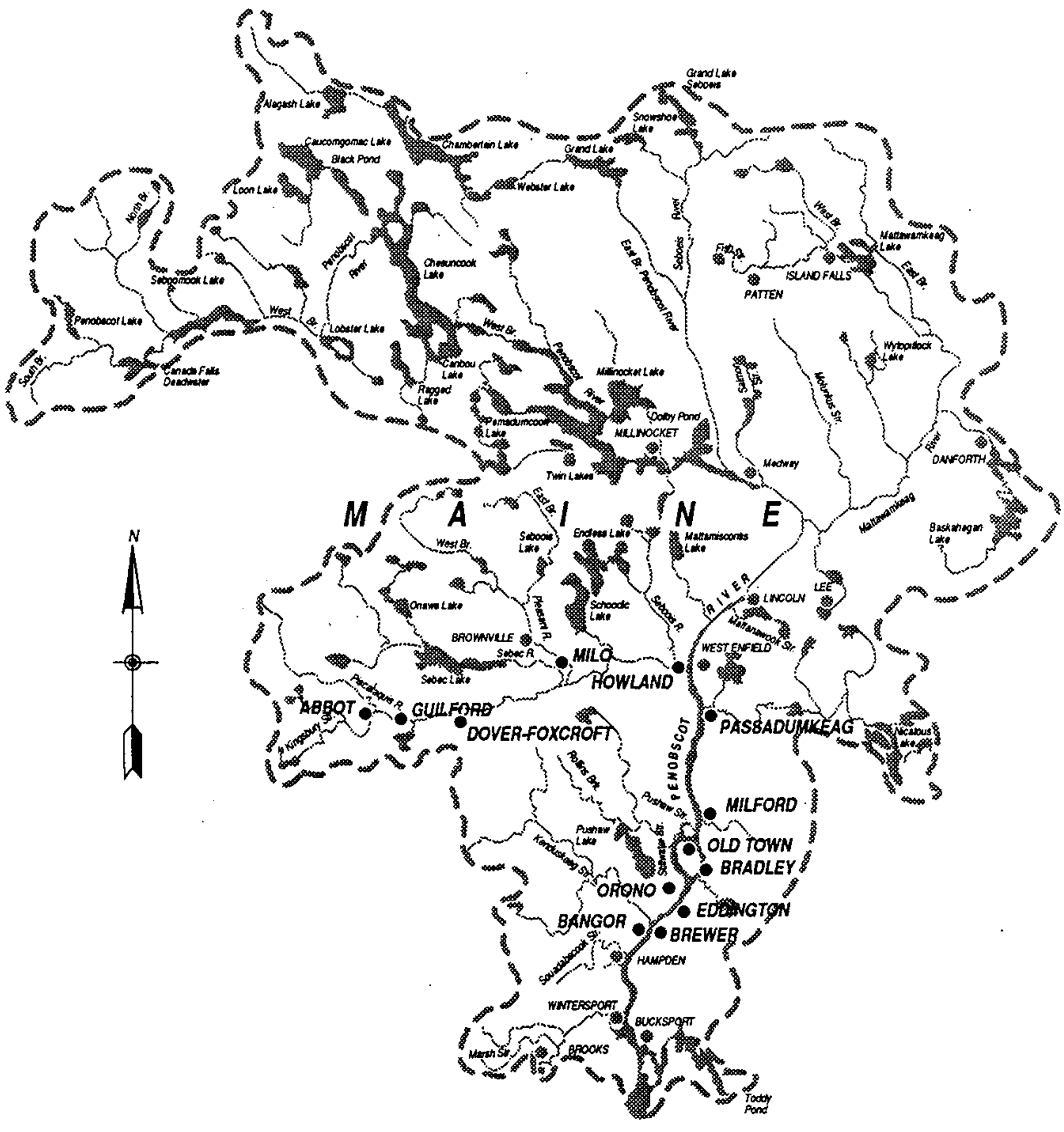
The Passadumkeag River is formed by the junction of its East and West Branches in Township 3, Range 1, about 7 miles southwest of Springfield, and flows in a general westerly direction for 43 miles to its confluence with the Penobscot River at Passadumkeag, 42.5 miles below Medway. It has a drainage area of 385 square miles and a total fall of nearly 152 feet. Lakes account for 6 percent of the land area within the basin. The greatest fall occurs at Morrison Mill, 25 miles above the mouth, where there is a drop of 60 feet in 0.7 miles.

Kenduskeag Stream drains an area of approximately 215 square miles. Rising in the town of Corinth, it flows in a southeasterly direction to its confluence with the Penobscot River in Bangor. The stream is approximately 28 miles long with an average slope of 11.9 feet per mile. In addition to flowing through the urbanized center of Bangor, the Stream drains some of the most important agricultural land in the Penobscot River basin.

Dams and Reservoirs - Existing dams and other impoundments in the Penobscot River Basin have total usable storage capacity of approximately 1,570,000 acre-feet (about 68.39 billion cubic feet). This storage is located primarily in the watersheds of the West and East Branches of the Penobscot River and in the Piscataquis River Basin. Over 80 percent of the total storage in the Penobscot River Basin is located in the West Branch watershed, with 690,000 acre-feet controlled by Ripogenus Dam and 350,000 acre-feet controlled by North Twin Dam. In the watershed above North Twin Dam, an additional 230,000 acre-feet of usable storage is available in 16 small lakes and ponds. Storage in the East Branch totals about 150,000 acre-feet. Approximately 105,000 acre-feet is controlled by the dam at the outlets of Chamberlain and Telos Lakes and 41,300 acre-feet is regulated by the dam at Grand Lake. Within the Piscataquis River watershed, about 114,500 acre-feet is available in five lakes and ponds. In addition, there are smaller amounts of available storage in other tributaries of the Penobscot River.



Penobscot River Basin
Plate 2



Penobscot River Basin
FLOOD DAMAGE CENTERS
Plate 3

All of the storage on the East Branch Penobscot River (146,900 acre-feet) is operated by Bangor Hydro-Electric Company for power production at its plants on the main stem Penobscot River below Medway. The 1,308,500 acre feet of usable storage in the West Branch Penobscot River is operated by Great Northern Paper Company for power purposes. Within the Piscataquis River Basin, the majority of available storage (105,600 acre-feet at Schoodic, Seboeis, Sebec and Endless Lakes) is owned and operated by Bangor Hydro-Electric Company to regulate flows at its plants on the Sebec, Piscataquis and Penobscot Rivers. The remaining storage (8,950 acre-feet at Wilson Pond) is used by the Central Maine Power Company to develop power at its plant on Wilson Stream. Appendix B contains additional detailed information concerning available storage in the basin.

Climatology - The Penobscot River Basin has climate generally classified as cool semi-humid continental, which can be quite variable within the basin due to variations in elevation. The summers are relatively cool and the winters, especially at inland points, are usually severe. The basin lies in the path of the"prevailing westerlies" and the cyclonic disturbances that cross the country from the west or southwest towards the east or northeast. The area is also exposed to occasional coastal storms, some of tropical origin, that travel up the Atlantic seaboard. Due to its northern location, the basin has escaped the brunt of coastal hurricanes, with their accompanying intense winds and rainfall.

The basin's average annual temperature is 42 degrees F. The range of mean monthly temperatures is wide, from 63 to 68 degrees F. in July and August to 12 to 20 degrees F. in January and February. Temperature extremes range from occasional highs over 95 degrees F. to lows below -10 degrees F. Average annual precipitation is 41 inches distributed uniformly throughout the year. Most of the winter precipitation is in the form of snow. Annual snowfall varies from about 70 inches at Old Town to 120 inches at Ripogenus Dam. Water content of the snow cover in early spring is about six to eight inches; ten inches is common in the upper areas of the watershed. Additional information concerning precipitation and temperature variations for areas within the basin is shown in Appendix B.

Topography - The Penobscot River Basin, located in east central Maine, spans several physiographic units. From north to south it includes parts of the Central Highlands, Coastal Lowlands, and the New Brunswick Highlands. Much of the Penobscot Basin is upland with low, rolling hills rising above wide, flat valleys. Scattered throughout the basin, particularly in the northern portion, are monadnocks of resistant rocks which rise to considerable elevations above the surrounding hills. The principal lowland of the basin is in the valley of the main river which extends from the estuary northward to the "great bend" below Millinocket. The surface of the basin has been modified by glaciation and, in the lower basin, by marine invasion. There is evidence of progressive down warping of the coastal zone.

The headwaters lakes of the Penobscot River are at an elevation of 1,040 feet, the general level of the Moosehead - Katahdin upland. The surrounding hills rise to elevations of 1,500 to 1,800 feet with Mt. Katahdin, rising to an elevation of 5,267 feet at Baxter Peak, the highest point in Maine. The main Penobscot River, in its southerly course from

Medway to Bangor, flows through a region of low relief with the hills near the river rising to elevations of 300 to 400 feet, and divides on the perimeter of the valley reaching elevations of 600 to 800 feet. Monadnocks in the middle reaches of the valley reach elevations of 1,200 to 1,400 feet.

Geology - The terrain of Maine is largely a glaciated rock-controlled landscape. The bedrock geology is complex as a result of a long and complicated sequence of dynamic geologic events that includes sediment deposition and rock formation, igneous activity, metamorphism, folding, faulting, and erosion. The principal features of the regional structural geology are northeast-southwest oriented synclines (troughs), anticlines (arches), and faults with interjected plutonic masses. During episodes of continental glaciation, Maine was covered by extensive ice sheets. As glacial ice advanced over the landscape, rock surfaces were eroded and valleys deepened in places while in other areas deposits of glacial till were laid down. As the glaciers retreated, a variety of unconsolidated deposits were left covering most of the area. The glacial ice cover was so extensive that the land was depressed and there was inland inundation of the sea. Marine deposits are found far inland along the valleys. Modern drainage patterns are largely controlled by topography influenced by bedrock.

In general, the bedrock of the Penobscot River Basin consists largely of metasedimentary types extending over most of the basin with interspersed volcanics in the northern and eastern parts, and numerous plutonic emplacements throughout. The structural arrangement of individual rock types and their resistance to erosion relate directly to topography. Mt. Katahdin, the highest point in Maine, and the mountainous surroundings are granite. The lower areas are usually underlain by rocks that are less resistant to erosion.

The Penobscot River Basin is covered by a variety of surficial materials that are of glacial origin. Glacial till is, by far, the most widespread material. It is a heterogenous mixture of particles from clay to boulders in size and generally has low permeability. Till is found at all elevations except at the highest peaks. It is often found at the surface directly on top of bedrock as well as in valleys overlain by subsequent water-laid deposits.

Sands and gravels deposited by glacial meltwaters form a variety of topographic features primarily at lower elevations at the sides of hills and in valleys. Fine grained sediments are found where lakes once stood. There are extensive deposits of gray generally fine-grained marine sediments, known as the Presumpscot Formation, that extend up the valleys from the coast as far inland as Medway. The formation is commonly clayey silt but may be mostly sand in places.

Seismicity - Maine has a history of seismic activity. Earthquakes occur in Maine from local sources as well as from surrounding areas. Documentation of historic earthquakes shows a concentration of significant earthquake activity in the St. Lawrence Valley to the north. Although many earthquakes with epicenters within Maine were very minor and were largely unnoticed, several stronger earthquakes have occurred. In 1943, for example, an earthquake with its epicenter near Dover-Foxcroft was reportedly felt over an area of 50,000 square miles. Although there are a number of historic earthquakes centered in Maine, an overall assessment places the Penobscot River Basin in Zone 1 of the seismic zone map of the Department of the Army, U.S. Army Corps of Engineers Engineering Regulation 1110-1-1806. This is a zone of minor potential damage from earthquakes. Seismic activity primarily affects the walls of structures. Retaining walls should be designed against an earthquake acceleration of 0.05g.

Water Quality - Historically, water quality of the lower reaches of the Penobscot River was severely degraded by municipal sewage, wastes from paper mills, woolen mills, and tanneries, and other effluents (Dow, 1939). With enactment of the Federal Clean Water Act in 1972, and the subsequent treatment of most major point sources of contamination, river water quality has greatly improved.

Current State of Maine Water Quality Classification for stretches of the Penobscot and Piscataquis Rivers under study are presented in Table 1, Appendix C. River water quality at all study sites, except Howland and Abbot, has been designated as class "C". Class "C" waters are suitable for the drinking water supply (after treatment), fishing, recreation (in and on the water), industrial process and cooling water supply, hydroelectric power generation, navigation, and as a habitat for fish and other aquatic life. Waters at Howland and Abbot have been classified as class "B". Class "B" waters are considered suitable for the above mentioned purposes, and retain their full capacity to support aquatic life.

Elsewhere in the Penobscot basin river waters are generally of high quality. Waters in the East and West Branches are typically classified as either Class "A" and "B". Overall, 87 % of the Penobscot (main stem), and nearly 100 % of the East and West Branches are suitable for contact recreation and for the protection and propagation of fish and wildlife resources.

Water quality at several sites fails to meet water quality objectives. The Sebec River in Milo fails to meet Class "C" standards because of high bacterial levels caused by the discharge of untreated residential wastewater. A 34 mile section of the Piscataquis River between Guilford and Medford Center (including the Dover-Foxcroft study area) fails to meet Class "C" bacterial standards. In addition, an eight mile section below Guilford fails to meet Class "C" aquatic life standards because of discharges of untreated municipal and industrial wastewater. Piscataquis water quality below Guilford should improve with the completion of a secondary sewage treatment plant to process both municipal and industrial effluent. A section of the Piscataquis River in Howland fails to meet Class "C" standards for bacteria because of discharges of untreated municipal wastewater. Although water quality standards are not violated, periodic discharges of untreated wastewater and combined sewer overflows can result in elevated bacterial counts in the main stem Penobscot below Veazie. Future water quality will be improved by a number of local treatment plants that are planned or underway.

Biological Resources - Nearly 95 % of the Penobscot River Basin is forested. Major forest types present in the basin are the "spruce-fir" and "northern-hardwoods" associations (see Ferris, 1980). The spruce-fir forest type is dominated by spruce (red, white, or black) and balsam fir. Other tree species commonly present include white cedar, eastern hemlock, eastern white pine, tamarack, red maple, paper birch, aspen, white ash, American beech, sugar maple, and yellow birch. Spruce-fir forests are commonly found in low areas with poorly drained soils, and on thin soils at higher elevations. The northern hardwood type is characterized by American beech, yellow birch, and sugar maple. Other common associated species include basswood, red maple, red oak, white ash, eastern white pine, balsam fir, cherry, paper birch, gray birch, American elm, slippery elm, hophornbean, red and white spruce, and hemlock (Ferris, 1980). The northern hardwood association is typical of areas with deep, moist, well drained soils. Common northern hardwood forest subtypes include aspen-birch, elm-ash-red maple, northern white cedar, grey birch-paper birch, and pin cherry. White pine-oak can be found on sandy, infertile sites.

Little specific published information is available concerning riparian vegetation occurring in the Penobscot River Basin. A list of species noted at specific sites along the Piscataquis and main stem Penobscot is presented in Appendix C. Frequently occurring trees and shrubs include red maple, red-osier dogwood, alder, box elder, birch (white, gray, and yellow), ash, elm, oak (including red oak), elderberry, and meadowsweet. Frequently occurring herbs include goldenrod, asters, Japanese knotweed, sensitive fern, and wild cucumber. Reed canary grass occurred at many sites.

Anadromous fish species occurring in the Penobscot Basin include Atlantic salmon, American shad, alewife, blueback herring, striped bass, rainbow smelt, and Atlantic sturgeon. Salmon, shad, and alewife were extraordinarily abundant prior to the construction of obstructing dams and the degradation of water quality by industrial discharges (Cutting, 1979). Runs of adult salmon in the Penobscot numbered between 45,000 and 75,000 before 1800, but were virtually extirpated by the 1950's. Runs of American shad, alewife, and undoubtedly other anadromous species, have also been drastically reduced.

Since the 1960's the State of Maine has been committed to the restoration of the Penobscot's anadromous fisheries resources (Maine DEC, 1982). The construction of functional fishways at dams, improved water quality, and an intensive stocking program has resulted in a resurgence of Atlantic salmon populations. Average runs of about 3,225 adult salmon occurred below the Veazie Dam between 1982 and 1987. At present, fish passage facilities provide salmon (and other anadromous species) access to all reaches of the Penobscot and Piscataquis under consideration in this study. Salmon were once abundant in the Piscataquis River system, and smolts and parr have been observed in recent years in the river and its tributaries. Current plans call for the passive restoration (i.e. with little or no stocking) of shad and alewife fisheries.

Historically, the Penobscot supported important commercial salmon and shad fisheries. At present, the river reportedly offers the nation's largest recreational Atlantic salmon fishery. Pools at the Bangor and Veazie Dams are probably the most productive and intensively fished waters for salmon in the Eastern United States. The mainstem Penobscot also supports a popular rainbow smelt fishery. The Orland River, a tributary on the lower Penobscot near Bucksport, supports an important alewife fishery.

Warm water fisheries are found at all study sites, and are comprised primarily of smallmouth bass (an introduced species), chain pickerel and yellow and white perch. Other fish species expected to commonly occur in reaches under study include red-breasted sunfish, longnose and white sucker, fallfish, blacknose dace, creek chub, common shiner, brown bullhead, American eel, and sea lamprey.

The Piscataquis River provides a quality recreational brook trout and smallmouth bass fishery, and offers good access for anglers. Brook trout are currently stocked in the Piscataquis by the Maine Department of Inland Fish and Wildlife. Annual plants occur in the Guilford to Dover-Foxcroft reach.

A list of bird species likely to occur in riparian habitats in the Penobscot River Basin is presented in Table 3, Appendix C. Birds noted during November, 1988 site visits include great blue heron, mallard, common merganser, double-crested cormorant, herring gull, belted kingfisher, American crow, black capped chickadee, American robin, song sparrow, and winter wren.

A list of mammals likely to occur in the Penobscot River Basin is presented in Table 4, Appendix C. Common species that could be expected to occur in riparian habitats include beaver, muskrat, mink, snowshoe hare, raccoon, striped skunk, porcupine, eastern chimpmunk, woodchuck, mice, shrews, voles, grey and red squirrel, red fox, and white tailed deer. Evidence of beaver was noted at many study sites.

Threatened, Rare, and Endangered Species - The Penobscot Basin provides both nesting and overwintering habitat for the bald eagle, a federally listed species (see August 22, 1988 and January 30, 1989 letters from Gordon Beckett, U.S. F.W.S.). Several nesting sites exist along the mainstem Penobscot and its tributaries. Nesting birds are known to forage along the lower Passadumkeag River, and roost on islands near the river mouth. The river from Bucksport to Veazie dam is regarded as one of the most important areas for wintering bald eagles in the state (Maine DEC, 1982). Overwintering birds tend to concentrate around open water areas, particularly below dams, and have been observed in the vicinity of the Howland and Great Works dams during December through March.

The shortnose sturgeon, an endangered anadromous fish, is known to occur in the Penobscot River estuary.

A number of endangered, threatened, or rare plants may occur in riparian habitats along the Penobscot and Piscataquis rivers. Extant and historic records for species occurring at or near study sites are summarized in Table 5, Appendix C (see also March 20, 1989 letter from Francie Tolan, Maine Natural Heritage Program). Shining Ladies'-tresses (Spiranthes lucida) a threatened species in Maine, and a rare sedge (Carex hassei) are reported from the Dover-Foxcroft study site. Lampsilis cariosa is reported to occur at the Passadumkeag study site.

Historic and Archaeological Resources - The historic development of Penobscot Valley towns occurred largely as a result of the development of the lumber industry during the 19th century. Most communities on the Penobscot River were dependent on the lumber industry which had a dominant position in the local economy. The rise and fall of many of these towns can be tied to the rise and fall of the lumber industry. Several of these towns such as Milford and Old Town had their economy run by lumber barons who controlled all log booms and water privileges. Other villages like Brewer had several diverse industries such as ship building and brick making, so were better able to develop more independently of lumber manufacturing and its periodic fluctuations.

The development of the Penobscot River towns led to the construction of churches, residences, mills and dams, some of which have become part of the historical record. Evidence of the lumbering industry and other manufacturing activities still remain along the Penobscot River in the form of dams, mills and factories.

There are over 185 known prehistoric sites dating from 8300 B.C. to A.D. 1750 along the Piscataquis and Penobscot Rivers from the town of Abbot to Brewer (see Appendix D). Prehistoric archaeological sites are present on many different landforms within the riverine environment. Concentrations of sites occur at tributary stream junctions and falls as well as on river terraces and floodplains. The currently known inventory of sites suggests that the Penobscot River Basin has received nearly continuous use as a habitation/resource exploitation area for at least the past 8,000 to 10,000 years.

In 1912 an avocational archaeologist reported a large site at the mouth of the Piscataquis River on the northern side of the confluence with the Penobscot River in Howland. Although this area has never been tested by professional archaeologists, many prehistoric artifacts are still located in this area by amateurs and collectors.

The brief summary report (see Appendix D) has documented the existence of over 185 known prehistoric sites. Given the relatively limited area that has been intensly studied, this number is likely to represent only a small portion of the overall preserved sample of prehistoric archaeological sites in the study area. However, given the concentration of prehistoric sites within the areas in the Penobscot River Basin which have been studied, this preliminary analysis of available information illustrates that the river's edge and floodplain have been extensively used by prehistoric groups.

FLOOD PROBLEM

The history of floods in the Penobscot River Basin goes back nearly 150 years with records indicating the occurrences of floods in 1846, 1853, and 1866, and on the Piscataquis River in 1857, 1869, and 1895. However, information on the relative magnitude of flood events is generally not available prior to 1901 when a gage was established at West Enfield by the U.S. Geological Survey. Major floods in the Penobscot basin are caused principally by a combination of heavy rainfall and melting snow in the spring of the year. Nearly all the flood events occur during the months of March, April and May and vary in magnitude depending on the water content of the melting snow cover, the occurrence of coincidental heavy spring rainfall, temperature and the extent of frost. The four greatest known floods; April/May 1923, March 1936, April/May 1973 and March/April 1987, were a result of combination of these factors. Historically, over 40 percent of the total basin runoff occurs during this three month period. Discharges and stages of spring floods can also be increased due to the formation of the ice jams. This occurred throughout the basin during the March 1936 event. Heavy rainfall at other times can also produce flooding as evidenced by the floods of September 1909, June 1917, November 1943, and November 1950.

May 1923 Flood - The flood of May 1, 1923 was the greatest known flood on the Penobscot River. It was caused by three days of rainfall on a snow-covered basin. The storm had a maximum recorded precipitation of 5.3 inches at Millinocket. Considerable damage was done to streets and houses in Costigan, Bradley and Old Town. The latter was without power, water or electricity for several days. The major property losses during this event consisted largely of damages to dams and mills. Flow at the West Enfield gage was recorded at 153,000 cfs. Due to lack of data, this flood could not be analyzed hydrologically.

March/April 1987 Flood - The March/April 1987 flood, the second largest basin-wide storm, was caused by a pair of intense rainstorms, augmented by snowmelt in the higher elevations of the basin. The first storm occurred from 31 March to 1 April, and was a fast moving storm system with heavy rainfall, strong southerly winds, and temperatures in the 50's and 60's. Two to 4 inches of rain fell over the Penobscot on snowpacks with 3 to 5 inches of water equivalent. The second storm, 4 to 8 April, was an intense, slow-moving storm, which generally had the greatest impact on the southern and central parts of New England. About 1 to 2 inches of rain fell over the Penobscot River Basin. Major flooding was experienced in the Piscataquis River subbasin with lesser damages occurring on the lower part of the Penobscot from West Enfield to Bangor. This event produced the flood of record on the Piscataquis; the USGS estimated a peak flow at Medford of 85,000 cfs. The recorded peak flow on the Penobscot at West Enfield and Eddington was 145,000 and 152,000 cfs, respectively.

April/May 1973 Flood - One of the more recent flooding events to affect the general Penobscot area occurred on April/May 1973 and was produced by 3 inches of rainfall over the basin during the snowmelt season. As in the past, streets in Bradley were heavily damaged, homes in Costigan and Old Town were flooded, over $60,000 of industrial damage was reported in Old Town, and Route 2 throughout Costigan area was inundated. Peak flow at the West Enfield gage was measured at 128,000 cfs.

March 1936 Flood - Although flows from March 1936 flood were less than 1973, 1987 and 1923 storms, ice conditions along Penobscot and Stillwater Rivers created significant problems in the lower Penobscot River. Severe winter conditions resulted in frozen ground, deep snows, and thick ice deposits in the upstream reaches of the Penobscot. The conditions, coupled with the heaviest amounts of rainfall known in certain areas, resulted in record flooding and damage in many river basins in Maine. Throughout the lower basin area, huge ice packs threatened at the highway bridges. Although the pesk discharge at West Enfield was 125,000 cfs, due to the extent of ice, experienced stages along the lower Penobscot were comparable to the recent April 1987 event. Flow of the Penobscot at Milford Dam records show 87,500 cfs, and records of the Stillwater River at Gilman Falls indicated a peak flow 38,000 cfs.

ANALYSIS OF FLOODS

To determine the flood potential of the basin and to identify tributaries or subwatershed areas that have the greatest impact on flooding, the three most recent floods of record (1936, 1973 and 1987) were analyzed. The basin was divided into reaches with key index stations, the mouths of larger tributaries, and other selected points, particularly along the Piscataquis and Penobscot Rivers. Stream flow records from the U.S. Geological Survey, Bangor Hydro-Electric and Great Northern Paper Company were used where available in the analysis. The following paragraphs summarize this analysis, with the complete analysis presented in Appendix A. Resultant flood hydrographs and tributary contributions for the three floods analyzed are also shown in Appendix A on Plates 4,5 and 6.

The first area analyzed was the headwater portion of the basin consisting of the West Branch and East Branch Penobscot Rivers. The West Branch has historically contributed very little to flood events due to it's large reservoir storage capacity. This storage capacity is operated by the Great Northern Paper Company for power generation. Operation of these reservoirs normally results in a gradual drawdown throughout the summer, fall and winter, making a large portion of these reservoirs available for storage of spring runoff. Historically, this operation has greatly reduced the West Branch's contribution to main stem flood peaks, as was the case during the 1936 and 1987 floods. However, if reservoir levels are high which was apparently the case in May 1973, contributions to flooding can be higher. The East Branch watershed, on the other hand, normally contributes to main stem flood peaks. The only significant amount of available storage is the Telos - Chamberlain Lake system in the upper watershed. The remainder of the watershed (about 77 percent of the total) has little storage and historically has contributed to flood flows.

The next area analyzed was the reach of river from Medway to West Enfield. About 85 percent of this intervening drainage area is contained in the two large tributaries, the Mattawamkeag and Piscataquis Rivers. The principle flood-producing tributary in this reach is the Piscataquis River with lesser contributions from the Mattawamkeag River. Since the Piscataquis River historically has been a major contributor to peak main stem flows, a more detailed hydrologic analysis of this watershed was undertaken. The results indicate that the Pleasant River and uncontrolled local area are significant contributors to Piscataquis River peak flood flows. The Piscataquis River above Dover-Foxcroft is also a major contributor to peak flow at the mouth. The Sebec River, with a relatively large amount of available storage, has been a lesser contributor to main stem peaks.

The final reach analyzed was the area from west Enfield to the Bangor Water Works Dam (partially breached). Contributions to peak Penobscot River flows from this portion of the basin have been relatively minor, due to the sluggish nature of intervening tributaries. For the most part, peak flood flows on the main stem are composed of runoff from areas above West Enfield.

EXISTING FLOOD CONTROL PROJECTS

There is one Corps of Engineers flood control project in the basin. It is located on Indian Island in Old Town and provides flood protection to 4.5 acres of low-lying land on the southern end of the island. The project consists of two earthen dike structures located on the west (700 feet long) and east (560 feet long) sides of the island. The project was completed in November 1976 and is operated and maintained by the Penobscot Tribe.

FLOOD DAMAGES

An estimate of losses experienced in the Penobscot River Basin during the April 1987 flood was provided by the State of Maine. This damage assessment, which was itemized by community, included estimated individual business losses and total public and individual assistance payments. The total estimated losses for communities in the basin were estimated by the State at $9.1 million and total assistance payments were estimated at $3.1 million.

Due to the size of the basin and number of communities along its rivers, an initial screening process was utilized to focus investigation on areas with a high potential for flood damage. Numerous meetings were held with state, community, and other officials to identify specific areas that either experienced severe flooding during 1987 or have a high potential for future flooding. Based on this screening process, a total of 13 communities were selected for analysis. Total damages in these communities account for more than 90 percent of the damages reported during the April 1987 flood. The communities selected for analysis are listed below, and their location is shown on Plate 3.

Abbot	Old Town
Guilford	Orono
Dover-Foxcroft	Bradley
Milo	Eddington
Howland	Brewer
Passadumkeag	Bangor
Milford	

Flood Damage Survey - A flood damage survey was performed in the 13 communities by a flood damage evaluator from the New England Division during September to November 1988. Flood related losses were estimated for each floodprone structure and site beginning at the elevation at which discernible losses and damages are first incurred up to the flood elevations of a rare and infrequent (500 year) event. The reference point at each structure was the first floor elevation. Ground and first floor elevations of all structures in the identified damage centers were obtained by survey crews during December 1988 and January 1989. These elevations were utilized to add confidence to the estimates of annual losses and benefits. The damage evaluators conducted interviews with knowledgeable local people concerning flood losses to commercial, industrial and public activities. For residential properties, use of sampling, typical loss profiles by type of house and minimal interviewing were employed. Both physical and non-physical losses were estimated. Damages to transportation, communication and utility systems were also obtained from the towns, the state of Maine Department of Transportation and pertinent electric utility companies.

Recurring and Annual Flood Losses - Recurring losses are the potential flood related losses which are expected to occur at various stages of flooding under present day development conditions. As the final output of the flood damage survey process, recurring losses are estimated as an array of dollar losses, in one foot increments, from the start of damage to the elevation of a rare and infrequent (500-year) flood event. Total recurring losses for selected events in the damage centers of the cities and towns under investigation are shown in Table 1.

TABLE 1
RECURRING LOSSES

	Recurring Losses for Selected Events			
Community/Damage Center	10 Year	50 Year	100 Year	500 Year
Abbot	$ 0	$4,200	$6,900	$29,000
Bangor	35,200	176,900	345,000	1,186,500
Bradley	86,400	410,100	768,800	1,579,200
Brewer	30,800	174,600	461,500	1,138,200
Dover/Foxcroft	1,800	140,200	393,900	1,061,100
Eddington	200	13,000	15,900	104,500
Guilford	93,900	859,500	1,560,500	3,483,100
Howland	193,000	364,000	608,100	2,366,300
Milford*	211,200	1,048,500	1,948,700	4,345,300
Milo	45,200	719,400	1,350,900	2,211,100
Old Town	316,500	958,300	1,350,500	2,126,900
Orono	27,700	119,900	265,000	873,100
Passadumkeag	64,700	315,100	674,200	1,720,000
TOTAL	**$1,106,600**	**$5,304,000**	**$9,749,900**	**$22,224,300**

*Includes village of Costigan

Annual losses for the same communities/damage centers have also been estimated to measure the severity of potential flooding on an "expected annual" basis. Annual losses are the integration and summation of two sets of data at each damage location. Recurring losses for each flood elevation (event) are multiplied by the annual percent chance of occurrence of that event. The resultant annual loss figure represents the average annual damage that can be expected at identified damage centers. Table 2 summarizes annual losses at these damage centers.

TABLE 2
ANNUAL LOSSES

Damage Center	Annual Losses
Abbot	$300
Bangor	20,900
Bradley	67,700
Brewer	27,000
Dover/Foxcroft	12,600
Eddington	1,200
Guilford	65,900
Howland	96,700
Milford*	109,300
Milo	50,500
Old Town	114,400
Orono	14,500
Passadumkeag	34,300
TOTAL	**$615,300**

*Includes the village of Costigan

EXPECTED FUTURE CONDITIONS

Existing and future activities on coastal floodplain land in the study area are regulated and/or controlled by numerous laws and policies. The National Flood Insurance Program, administered by the Federal Emergency Management Agency (FEMA) is currently in force for most communities in the lower basin. Under this program flood insurance zones and base flood elevation lines are established for each community. Subsidized flood insurance is then made available based on Flood Hazard Factors of areas subject to flooding. To be eligible for Federal flood insurance, a community must adopt floodplain regulations to protect life and property from flooding, and control development in areas that are subject to flooding.

The State of Maine has also been very active in establishing programs to control development in floodplain lands. One of the most important is Title 38 of the Maine Revised Statutes Annotated. Title 38 established shoreland area setback requirements to, among other things, "protect buildings and lands from flooding and accelerated erosion."

The impact of the above programs will be to limit and control future development of floodplain lands. Consequently, future flood damages are expected to remain relatively constant, with some increases in damage due to future development of upland areas and the resultant increase in runoff. Average annual flood losses for identified damage areas in the thirteen communities has been estimated at about $625,000.

STATEMENT OF PROBLEMS AND OPPORTUNITIES

The authorizing resolution for the Penobscot River Basin study provided the basis for identification of the problems and opportunities in the study area. Identified needs in the Penobscot River Basin were based upon a preliminary assessment of current conditions and coordination with local, State and Federal agencies. This coordination determined that non-Federal interests considered flood damage reduction to be the primary need within the Basin. The resulting statement of desired outputs for the study were used to guide the formulation of alternative plans, assessment of impacts, and evaluation of each plan. Problem and opportunity statements are as follows:

1. Reduce future flood damages along the Penobscot River and its tributaries, particularly in the 13 communities identified in this study.

2. Assist in the preservation of environmental and cultural resources, and fish and wildlife habitat within the Penobscot River Basin.

3. Provide where possible, additional contributions to water and related land recreational resources within the Penobscot River Basin.

4. Enhance, wherever possible, water quality for supply, irrigation, recreation, and aesthetic purposes in the Penobscot River Basin.

PLANNING OBJECTIVES AND CRITERIA

Recommendations to proceed to the next study stage (feasibility phase) were guided by two general criteria:

1. Information be sufficiently detailed to determine that at least one potential solution will likely have Federal interest and be in accord with current policies and budgetary priorities; and

2. The potential solution be supported by the non-Federal sponsor, and be consistent with their policies and statutes on flood plain management and flood control. Since this study focused on flood damage reduction, Federal interest was established if a potential solution was economically justified and the non-Federal sponsor demonstrated support for further study.

Based on an assessment of the problems and opportunities of the study area, and the goals of the non-Federal sponsor, the State of Maine the study has concentrated on the following planning objectives:

1. Reduce potential flood damage in the 13 communities.

2. Preserve or enhance the environmental and cultural resources of floodplain areas.

SECTION III

ALTERNATIVE PLANS

MEASURES AVAILABLE TO ADDRESS THE FLOOD PROBLEM

To prevent or reduce flooding and associated damage, there are two basic types of protection available; structural and nonstructural. Structural and nonstructural measures differ in that structural measures affect the flood waters while nonstructural measures affect activities in the floodplain. Nonstructural solutions to flood problems are normally applied directly to each flood plain property or activity, in contrast to structural measures which normally affect the floodplain. Both types of flood control measures, or possible combinations, are evaluated to address the flood problem.

Structural Measures - Structural measures are characterized as those measures that prevent or reduce inundation of the floodplain. The following structural measures, either singularly or in combination with others, represent potential solutions to flooding.

- Upstream Flood Control Reservoirs
- Dikes and/or Floodwalls
- Modification of Existing Dams

Nonstructural Measures - Nonstructural flood control measures are those measures which prevent or mitigate losses experienced by existing flood prone properties and activities, while allowing continued inundation of the floodplain. Applicable nonstructural measures are presented below:

Floodproofing Techniques - Floodproofing, by definition, is a body of techniques for preventing damages due to floods; requiring adjustments both to structures and to building contents. It involves keeping water out as well as reducing the effects of water either when buildings are under construction or during remodeling or expansion of existing structures. They may be permanent or temporary.

Floodproofing, like other methods of preventing flood damages, has its limitations. It can generate a false sense of security and discourage the development of needed flood control and other actions. Indiscriminately used, it can tend to increase the unwise use of flood plains resulting from unregulated flood plain development.

A floodproofing program would normally warrant serious consideration in the following circumstances:

- Where floodproofing is the most economically feasible solution;

- Where flood control projects are not feasible due to environmental or other serious impacts;

- Where reduced flood risk could lead to more favorable flood insurance rates; and

- Where existing flood control projects provide only partial flood protection.

Although numerous measures exist, the following techniques apply to the study area:

- Temporary or permanent closures for openings in existing structures

- Raising existing structures

- Rearranging or protecting damageable property within an existing structure

- Relocating existing structures and/or contents from a flood prone area.

Flood Forecast, Warning and Evacuation - This is a strategy to reduce flood losses by charting out a plan of action to respond to a flood threat. The strategy includes:

- A system for early recognition and evaluation of potential floods.

- Procedures for issuance and dissemination of a flood warning.

- Arrangements for temporary evacuation of people and property.

- Provisions for installation of temporary protective measures.

- A means to maintain vital services.

- A plan for postflood reoccupation and economic recovery of the flooded area.

Floodplain Regulations - Through proper land use regulation, floodplains can be managed to insure that their use is compatible with the severity of a flood hazard. Several means of regulation are available, including zoning ordinances, subdivision regulations and building and housing codes. Their purpose is to reduce losses by controlling the future use and changing the existing use of floodplain lands.

Some regulations covering the use of the flood plains are already in effect in the communities within the study area. Regulations may be relatively prohibitive or may allow construction, provided the new structures are floodproofed and/or elevated above a designated flood elevation.

Flood Insurance - Flood insurance is not really a flood damage prevention measure as it doesn't reduce damages. Rather, it provides protection from financial loss suffered during a flood. The National Flood Insurance Program was created by Congress in an attempt to reduce, through more careful planning, the annual flood losses and to make flood insurance protection available to property owners. Prior to this program, the response to flood disasters was limited to the building of flood control works and providing disaster relief to flood victims.

Utilization of nonstructural measures usually requires a combination of measures to adequately protect activities in a floodplain. For example, raising existing structures above projected flood heights would not completely solve the flood problem. Residents or other occupants must be warned of expected flooding so that the area can be evacuated. In addition, further development of the floodplain should be regulated to prevent future flood damages. Appendix E contains a detailed description of the above measures, including the advantages and disadvantages of each.

DEVELOPMENT, EVALUATION AND SCREENING OF ALTERNATIVE PLANS

During the initial phase of this reconnaissance study, numerous meetings were held with other Federal, State, regional, community and company officials and individuals. The purpose of these meetings was to identify potentially high damage areas and possible alternative flood damage reduction measures. In conducting the initial evaluation of selected flood prone areas, all methods of reducing or eliminating potential flood damage were given consideration. The communities/damage centers and various structural and nonstructural alternatives initially identified for study are shown on Table 3.

To determine which alternatives warranted further study, an initial screening process was conducted. Factors considered during this process included the potential for flood damage, the possible environmental and social impacts, engineering and economic feasibility, and public acceptability of identified alternatives.

Reservoirs - In evaluating the feasibility of upstream reservoirs, a total of eight reservoir sites were investigated. To be effective for flood control, the reservoir should be able to control six (6) inches of runoff from the contributing drainage area. Four of these sites, three on the East Branch Penobscot River and one on the Mattawamkeag River, were first investigated during the New England - New York Inter-Agency Committee (NENYIAC) study completed in 1954. The other four potential sites are located within the Piscataquis River watershed, which experienced substantial flood losses in the Flood of April 1987. The effectiveness of these reservoirs on downstream flood stages was then estimated to determine potential flood control benefits. Table 11 in Appendix A, lists these reservoirs, information on the size of the dam and its effect on downstream flood stages for a recurrence of the 1987 flood.

TABLE 3

INITIAL ALTERNATIVES CONSIDERED

Community/Damage Center	Upstream Reservoirs	Dikes and/or Floodwalls	Modification of Existing Dam	Flood Warning and Evacuation	Floodproof or Raise Structures
Abbot	✔			✔	✔
Guilford	✔	✔	✔	✔	✔
Dover-Foxcroft	✔	✔		✔	✔
Milo	✔	✔	✔	✔	✔
Howland	✔	✔	✔	✔	✔
Passadumkeag	✔	✔		✔	✔
Milford					
Village of Costigan	✔	✔		✔	✔
Remainder of Milford	✔	✔		✔	✔
Old Town					
Indian Island	✔	✔		✔	✔
French Island	✔	✔		✔	✔
South Water Street Area	✔	✔		✔	✔
Bradley	✔	✔		✔	✔
Orono	✔	✔		✔	✔
Eddington	✔			✔	✔
Brewer	✔	✔		✔	✔
Bangor	✔	✔		✔	✔

Of the reservoirs evaluated, only three were found to have an appreciable effect on main stream Penobscot River flood stages. Each of these reservoirs, Grand Lake - Sawtelle Falls and Whetstone Falls in the East Branch Penobscot River and Stratton Rips on the Mattawamkeag River, was found to reduce 1987 flood stages by 1.5 - 2.0 feet on the Penobscot River at West Enfield. To make an initial determination of the potential for interest in these upstream reservoirs, the annual cost of the smallest reservoir (Grand Lake - Sawtelle Falls) was compared with total average annual flood losses at identified damage centers along the Penobscot River. This includes the communities of Passadumkeag, Milford, Old Town, Orono, Bradley, Eddington, Brewer and Bangor. The total cost of the Grand Lake - Sawtelle Falls reservoir, updated to 1989 price levels, was approximately $40 million, resulting in an annual cost of about $3.6 million. In as much as this annual cost is far greater than total annual flood losses of $439,800, further Federal involvement in evaluation of the above reservoir sites is not warranted.

The next group of reservoirs evaluated were the four reservoirs in the Piscataquis River watershed. Two of these sites, one on Big Wilson Stream in Willimantic and the other on the East Branch Pleasant River, only reduced flooding in Milo and to a smaller degree in Howland. Due to their limited impact on flooding, they were eliminated from further consideration. The other two sites, on the East Branch Piscataquis River and on Kingsbury Stream, would reduce flood levels along the entire Piscataquis River and were evaluated further. Since both reservoirs would provide similar flood reductions, the smaller Kingsbury Stream reservoir was selected for further evaluation. The total construction cost of this reservoir was estimated at $10 million, which results in an annual cost of about $900,000. When compared with $184,600 in total annual losses at damage centers along the Piscataquis River, the cost of his reservoir exceeds potential flood reduction benefits. Consequently, further study of these flood control reservoirs was not justified.

As shown in the above paragraphs, an initial evaluation of potential reservoir sites determined that construction of upstream flood control reservoirs would not be economically justified. This is partially due to the relatively sparse development within the basin and the widespread nature of flood damages. In addition, the large storage capacity necessary to substantially reduce downstream flooding results in high reservoir costs.

Local Protection - During initial evaluation of the feasibility of localized structural plans, two primary factors were considered. First was the amount of expected average annual damages and the second was the potential cost of flood protective works. Project costs are governed primarily by the length and height of required protective measures. An important requirement at most sites is also the need to pump interior runoff (rainfall or other flows which collect behind the dike or wall) into the river. In most of the areas investigated, flood prone properties were dispersed linearly along the river. Protecting areas of this type results in very high costs due to the length of dikes or walls required, while flood preventions benefits for such work are relatively low due to the dispersion of damages. Consequently, investigation of dikes and/or floodwalls was limited to relatively densely developed areas which have a greater possibility of Federal assistance. In areas involving only a few structures or where flood prone properties are widespread, non-structural measures such as raising, floodproofing or early warning offered the best solution to flooding.

Nonstructural - The costs and benefits associated with an early warning and evacuation system were not analyzed on a community basis. Since the benefits of such a system would be regional, a warning system which concentrates on identified damage centers was evaluated.

As a result of this initial screening process, a list of potentially feasible alternatives was developed. These alternatives, shown on Table 4 (following page), were then analyzed to determine the costs and benefits of implementing each plan. Costs and benefits for these plans were developed based on providing protection from a 100-year flood event. Annual costs were developed using a project economic life of 50 years and the current Federal interest rate of 8 7/8 percent. The results of these analyses are described in detail in the following sections for each community.

Information contained in U.S. Army Corps of Engineers' publications and local cost figures were used to develop costs to raise or floodproof structures. Based on this information, the average cost to elevate an existing structure was determined to be about $45,600. This includes contingency costs, costs for engineering and design and supervision and administration of construction. Costs to floodproof structures depended upon the type of building and the number and size of openings requiring closure. For purposes of this evaluation, it was determined that the first floors of wood frame structures could not be floodproofed. These structures would have to be raised to prevent flood damage.

TABLE 4

FINAL ALTERNATIVES CONSIDERED

Community/Damage Center	Dikes and/or Floodwalls	Modification of Existing Dam	Flood Warning and Evacuation	Floodproof or Raise Structures
Abbot			✔	✔
Guilford	✔	✔	✔	✔
Dover-Foxcroft	✔		✔	✔
Milo			✔	✔
Howland	✔		✔	✔
Passadumkeag			✔	✔
Milford				
Village of Costigan			✔	✔
Remainder of Milford			✔	✔
Old Town				
Indian Island			✔	✔
French Island			✔	✔
South Water Street Area			✔	✔
Bradley	✔		✔	✔
Orono			✔	✔
Eddington			✔	✔
Brewer			✔	✔
Bangor			✔	✔

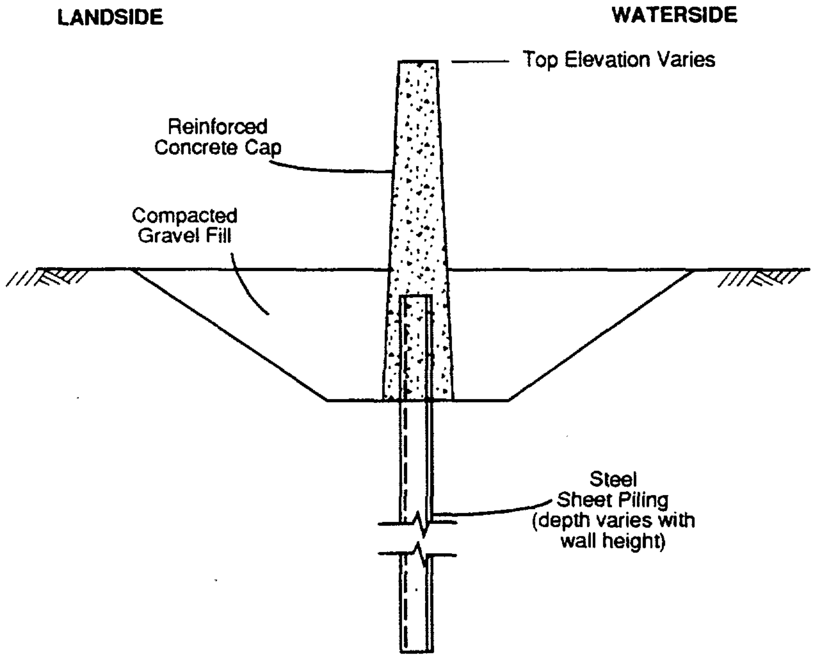
Costs for structural plans considered in this report were based on actual costs for similar work which were adjusted to reflect current costs in Maine. The design heights for dikes and floodwalls were determined using existing topographic mapping and 100-year flood elevations developed in Appendix A. Typical design features for dikes and floodwalls are shown on Plate 4. The first cost of the primary materials used in construction of these two types of protection are shown on Table 5. To arrive at total project costs, cost for contingencies, engineering and design and supervision and administration are then added to inplace construction costs.

TABLE 5

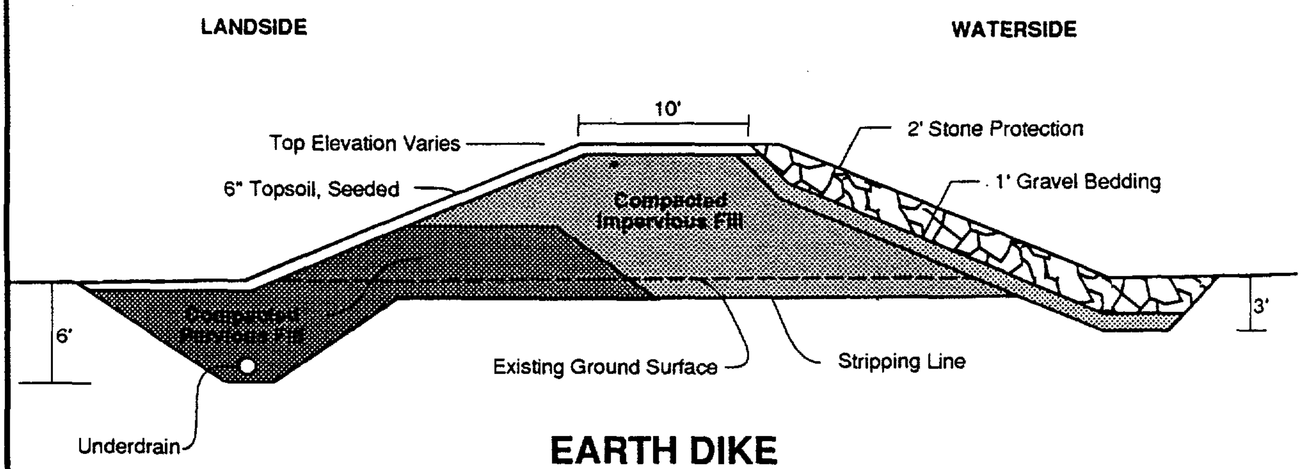
In Place Costs For Various Construction Materials

Material	Cost per Cubic Yard
Stone protection	$ 40.00
Compacted Gravel Fill	$ 20.00
Compacted Impervious Fill	$ 20.00
Compacted Random Fill	$ 10.00
Reinforced Concrete	$300.00

Benefits attributable to protective works considered in this study were developed by conducting damage surveys of study area and correlating these figures with data concerning the frequency and depth of flooding. The annual flood reduction benefits attributable to a plan are then measured by subtracting annual damages remaining with a plan from total annual damages expected under current conditions. Appendix B details this procedure and provides additional data concerning the economic analysis of the study areas.



I – WALL



EARTH DIKE

Penobscot River Basin Study

TYPICAL SECTIONS

US Army
Corps of Engineers
New England Division

ABBOT

Damage Center and Alternatives Studied - In Abbot it was determined that flood damages are widely scattered with very few structures susceptible to overbank flooding. Only three residential structures, located along Guilford Road were identified as flood prone. Plate 5 shows the general location of these homes. Of the alternatives initially considered, only floodproofing or raising structures and early warning and evacuation warranted further study.

Environmental Considerations - The Guilford Road location is characterized by widely scattered homes situated among fields and wet meadows. Meadow vegetation is characterized by reed canary grass, foxtail and other grasses. Species noted along Brown Brook and the Piscataquis River included alder, yellow birch, white birch, red osier, dogwood, elderberry, bigtooth aspen, sugar maple, elm and white pine. There would be essentially no environmental impacts associated with the nonstructural plans of floodproofing or raising structures and flood warning and evacuation.

Economic Analysis - The costs and benefits associated with floodproofing are shown in the following tabulation. Since one structure receives no damage from a 100-year flood event, the plan includes raising one home and floodproofing the basement of another.

	First Cost	Annual Cost	Annual Benefits	Benefit Cost Ratio	Net Benefits
Floodproof or Raise structures	$48,100	$4,300	$200	0.05	Negative

As shown above, the cost of floodproofing structures far exceeds flood control benefits and further study of this alternative is not justified. However, this community should be included in a regional flood warning and evacuation plan.

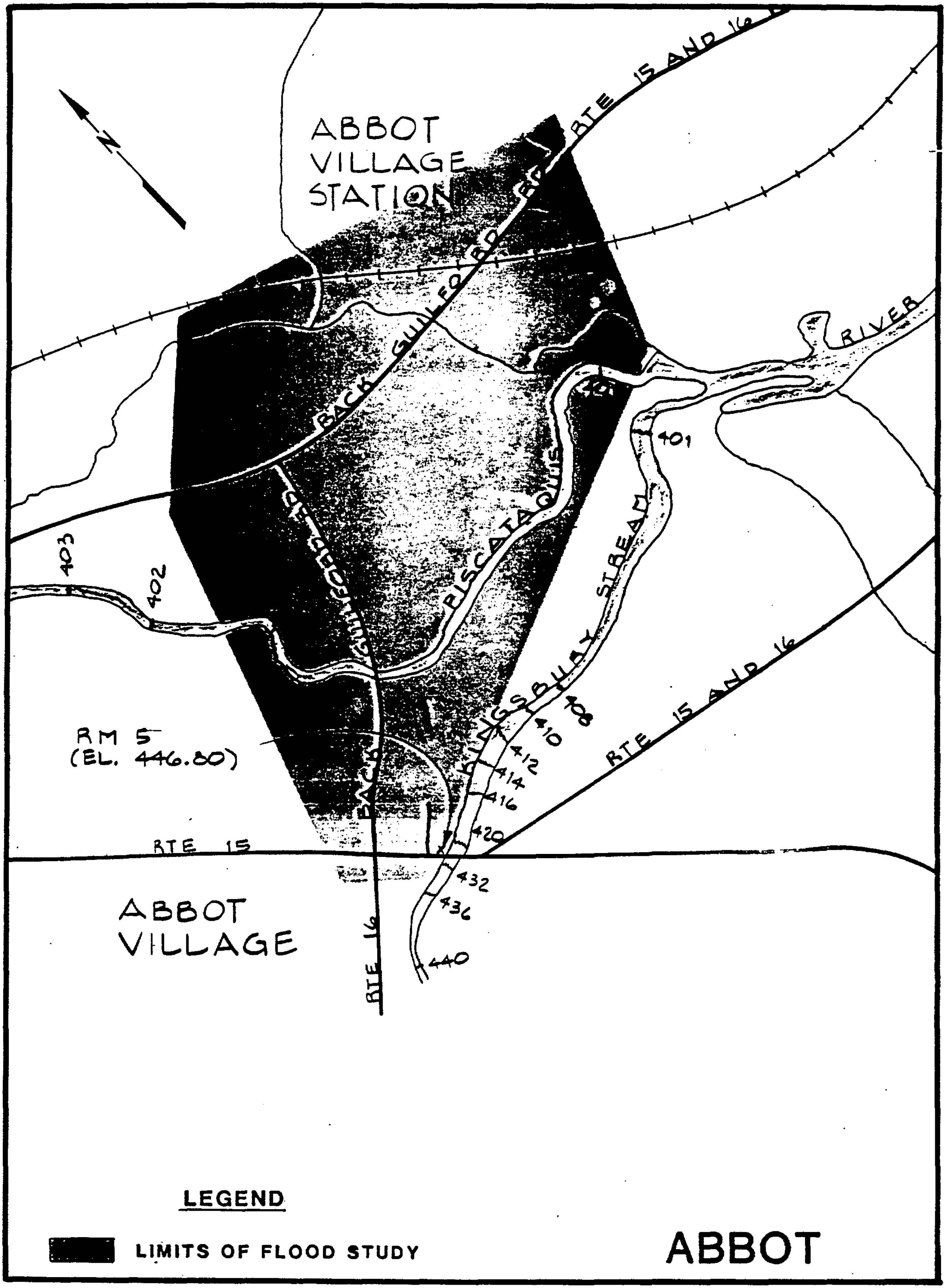

ABBOT VILLAGE STATION
N
RTE 15 AND 16
BACK GUILFORD RD
RIVER
PISCATAQUIS
KINGSBURY STREAM
401
403
402
408
410
412
414
416
420
432
436
440
RM 5
(EL. 446.80)
RTE 15 AND 16
RTE 15
ABBOT VILLAGE
RTE 16
LEGEND
LIMITS OF FLOOD STUDY
ABBOT

PLATE 5

GUILFORD

Damage Centers and Alternatives Studied - The potential for overbank flooding in Guilford is both extensive and widespread. Primary damage areas are located on the north bank of the Piscataquis River downstream of the Main Street bridge and along Elm Street, which is situated upstream of the Main Street bridge. Within these study areas, which are shown on Plate 6, a total of 47 residential, 17 commercial and 5 industrial structures have been identified as flood prone.

Alternatives initially considered include dikes or floodwalls, modification of the dam located just downstream of the Main Street bridge, floodproofing and raising structures and early warning and evacuation. Only one structural plan, which consisted of the installation of bottom hinged gates at the dam and construction of 400 feet of floodwall, warranted further study. The gates would be lowered during high river flows to reduce flood heights and the floodwall would prevent overbank flooding on the north bank of the river in the vicinity of the dam. The location of these project features are shown on Plate 7. Additional dikes or floodwalls in Guilford would not be feasible because damages are too widespread to justify the extensive length of protection required. The nonstructural alternatives of floodproofing or raising structures, and flood warning and evacuation were studied further.

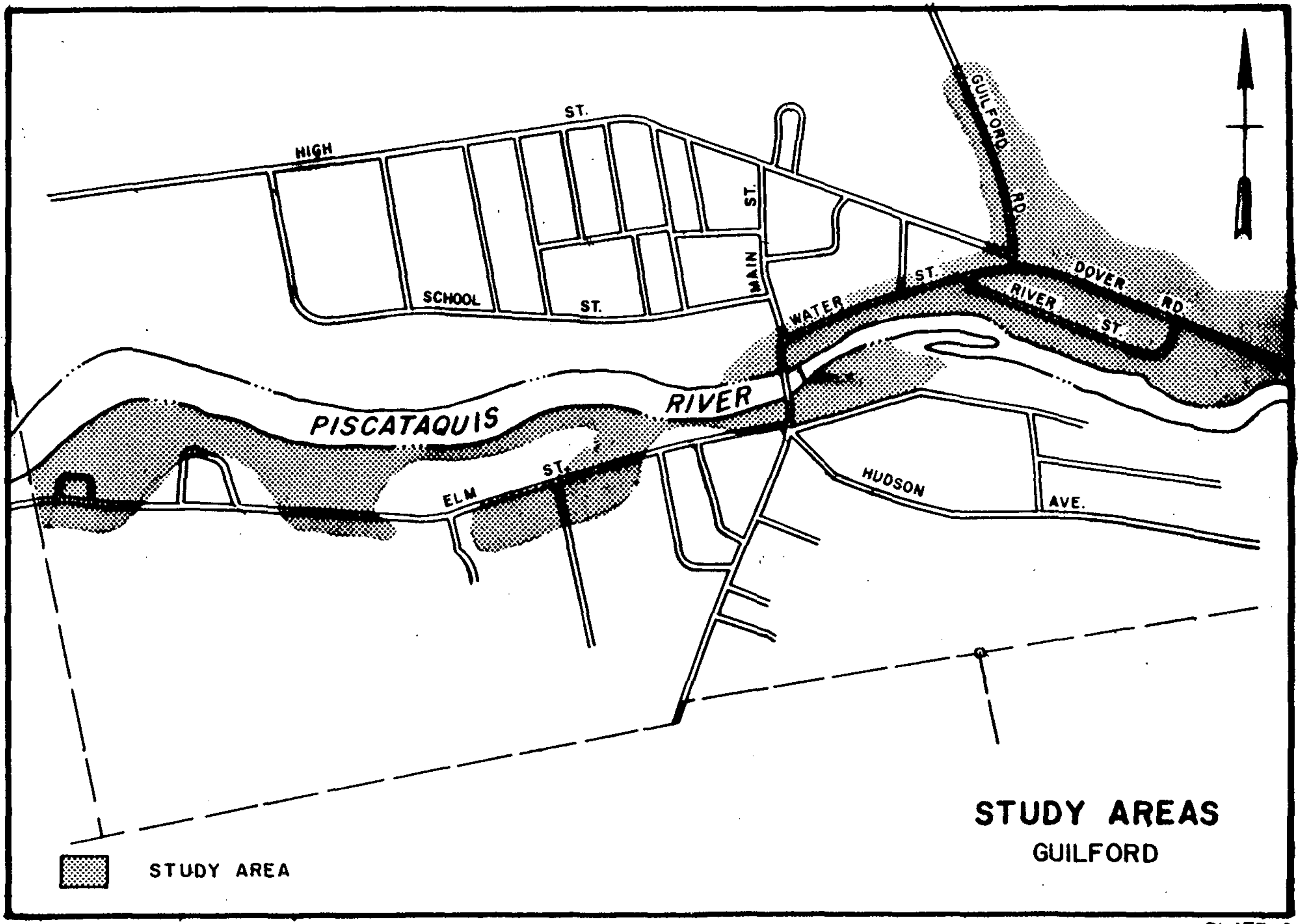
Environmental Considerations - The riverine environment in Guilford is characterized by several distinct areas. In the upstream reach along Elm Street, the flat zone adjacent to the river supports a variety of wetland vegetation. Species noted included reed canary grass, meadow sweet, golden rod, sedges, alder, raspberry, elderberry, red maple, grey birch, white birch, red-oiser dogwood, willow, aspen, mulberry, turk's cap lily and unidentified grasses. Further downstream, in the vicinity of the Main Street bridge, the area adjacent to the river is heavily developed and offers little habitat value. Vegetation along both sides of the river consists of a few scattered trees (white pine, elm, white birch and ash) and grasses. The riverbank is frequently abutted by buildings or parking lots. Below the bridge, along River Road vegetation is limited to scattered trees, such as red oak, red maple, and white pine, and grasses growing on or near the steep river banks. A well developed scrub/shrub wetland, dominated by alder, exists along Schoolhouse Brook.

Areas of specific environmental concern associated with modification of the dam and construction of the floodwall include the possible impacts on the effectiveness of the existing fish ladder, and water quality impacts during construction. Construction related impacts caused by cofferdams or other temporary structures within the waterway would also have to be addressed. There would be no significant environmental concerns associated with the nonstructural plans.

Economic Analysis - The following tabulation presents the costs and benefits of various flood control plans. Modifications at the dam would reduce flood stages for 24 properties upstream of the dam and 12 properties downstream. The nonstructural plan of raising or flood proofing structures was divided into two segments; the area above the dam and the area below the dam. The plan for above the dam included raising five structures and floodproofing seven basements. The plan for below the dam included raising 28 structures, and floodproofing the basements of three structures and the first floors of three others.

	First Cost	Annual Cost	Annual Benefits	Benefit cost Ratio	Net Benefits
Modification of Dam	$1,420,000	$127,800	$18,100	0.14	Negative
Floodproof or Raise Structures (Above Dam)	$ 246,000	$ 22,100	$ 6,600	0.30	Negative
Floodproof or Raise Structures (Below Dam)	$1,380,000	$124,000	$41,900	0.34	Negative

Based on the above analysis, the cost of flood control plans evaluated for Guilford exceed flood control benefits. Consequently, implementation of these plans would not be economically justified. Due to the potential for damage, Guilford should be included in any regional early warning and evacuation system.



STUDY AREAS
GUILFORD

PLATE 6

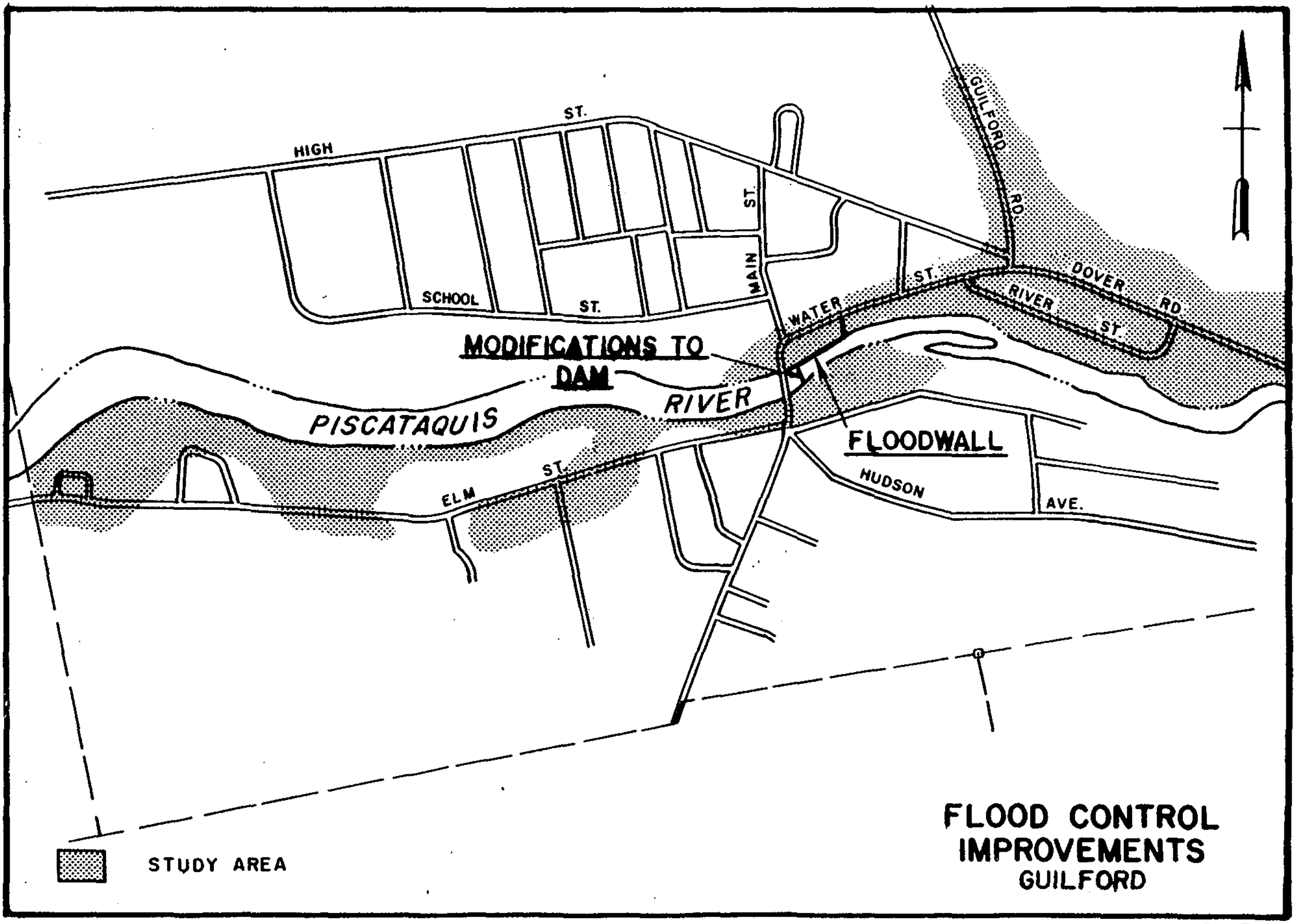

HIGH
ST.
SCHOOL
ST.
MAIN
ST.
GUILFORD
RD.
WATER
ST.
DOVER
RD.
RIVER
ST.
MODIFICATIONS TO
DAM
PISCATAQUIS
RIVER
FLOODWALL
ELM
ST.
HUDSON
AVE.
STUDY AREA
FLOOD CONTROL
IMPROVEMENTS
GUILFORD

PLATE 7

DOVER-FOXCROFT

Damage Centers and Alternatives Studied - Investigations in Dover-Foxcroft determined that there are 21 floodprone properties located in several study areas along the Piscataquis River. These study areas are shown on Plate 8. Due to the dispersion of flood prone properties, only one structural plan was considered. This plan, shown on Plate 9, would consist of a combination earth dike and concrete floodwall along the right bank of the river upstream of the East Main Street bridge. This plan would protect ten structures located along South Street from a 100-year flood. Two nonstructural improvement plans were also formulated for Dover-Foxcroft. The first included raising ten structures above the East Main Street bridge and the second recommended raising four first floors and floodproofing two basements of structures located below the bridge.

Environmental Conditions - The majority of the area adjacent to the river upstream of East Main Street has been developed. The north bank of the river has little habitat value and about 50 percent of the bank along this reach has been riprapped. Vegetation noted in this area includes golden rod, grasses, nightshade, box elder, and elm. The opposite (south) bank is largely devoid of vegetation. The portion abutting South Street is riprapped. A small cattail marsh is situated near the upstream limit of the study area. Species noted in or near the marsh include elderberry, wild cucumber, burreed, burdock, aster, goldenrod and grasses.

Due to heavy development upstream of the bridge and dam, construction of a dike and wall would cause minimal loss of wildlife habitat. Losses would be limited to vegetation on existing slopes and construction of floodwalls would minimize or avoid impacts to aquatic habitat. Nonstructural measures would entail essentially no impacts to existing habitat or fish and wildlife resources.

Economic Analysis - The following tabulation presents the costs, benefits and resultant benefit-to-cost ratios of alternatives considered.

	First Cost	Annual Cost	Annual Benefits	Benefit Cost Ratio	Net Benefits
Dike and Floodwall	$330,000	$29,700	$4,400	0.15	Negative
Raise Structures (Above East Main St.)	$456,000	$41,000	$4,100	0.10	Negative
Floodproof or Raise Structures (Below East Main St.)	$186,000	$16,700	$3,600	0.22	Negative

As shown in the above analysis none of the plans evaluated for Dover-Foxcroft were economically justified. Based on the potential for flood losses, these study areas should be included in a regional early warning system.

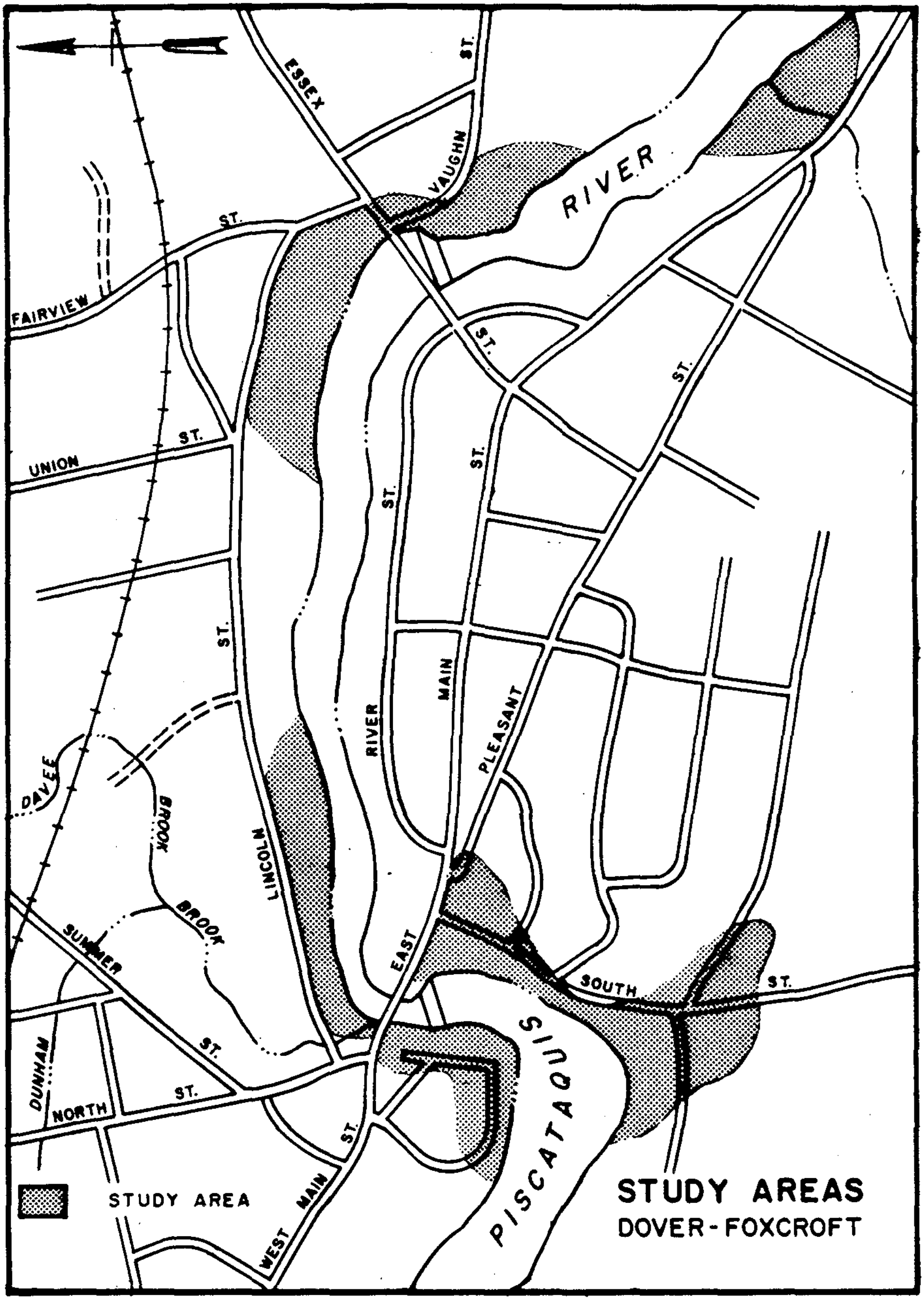

ESSEX
ST.
VAUGHN
RIVER
ST.
FAIRVIEW
ST.
ST.
UNION
ST.
ST.
ST.
ST.
RIVER
MAIN
PLEASANT
LINCOLN
DAVEE
BROOK
BROOK
SUMMER
EAST
SOUTH
ST.
ST.
DUNHAM
NORTH
ST.
ST.
PISCATAQUIS
MAIN
WEST
STUDY AREA
STUDY AREAS
DOVER - FOXCROFT

PLATE 8

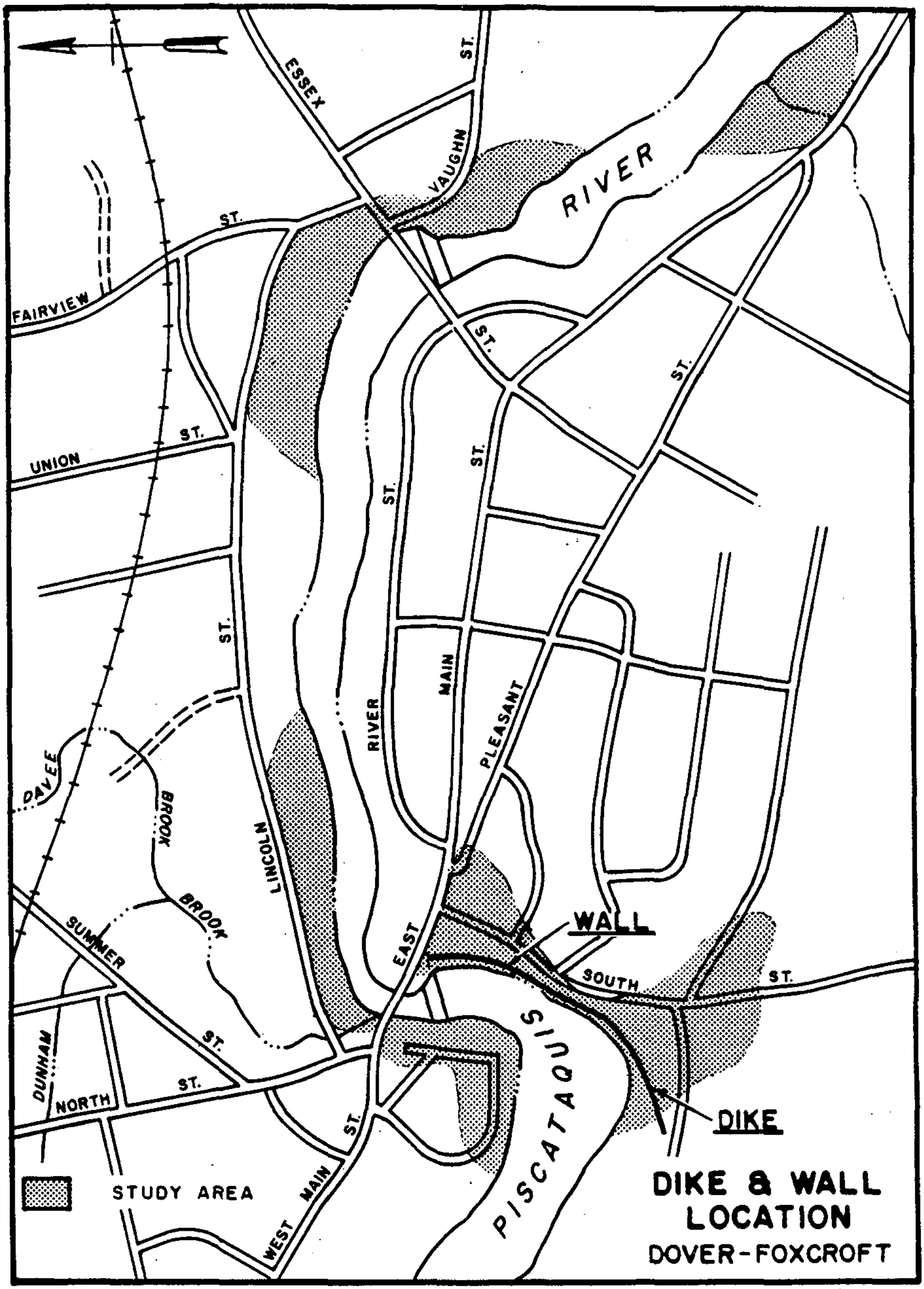

ESSEX
ST.
VAUGHN
RIVER
FAIRVIEW
ST.
UNION
ST.
ST.
ST.
MAIN
RIVER
ST.
ST.
PLEASANT
DAVEE
BROOK
BROOK
LINCOLN
SUMMER
EAST
WALL
SOUTH
ST.
ST.
DUNHAM
NORTH
ST.
ST.
PISCATAQUIS
DIKE
STUDY AREA
WEST
MAIN
DIKE & WALL
LOCATION
DOVER-FOXCROFT

PLATE 9

MILO

Damage Centers and Alternatives Studied - Flooding in Milo occurs both along the Sebec and Piscataquis Rivers. Sebec River flooding occurs primarily in the Main Street area and at low points situated along the river both above and below the Milo Dam. Flooding along the Piscataquis River is more widespread and occurs in several areas along Lyford Road and Ferry Road. A total of 45 structures, 27 residential, 14 commercial and four public are located in these areas. The limits of the flood control study in Milo are shown on Plate 10.

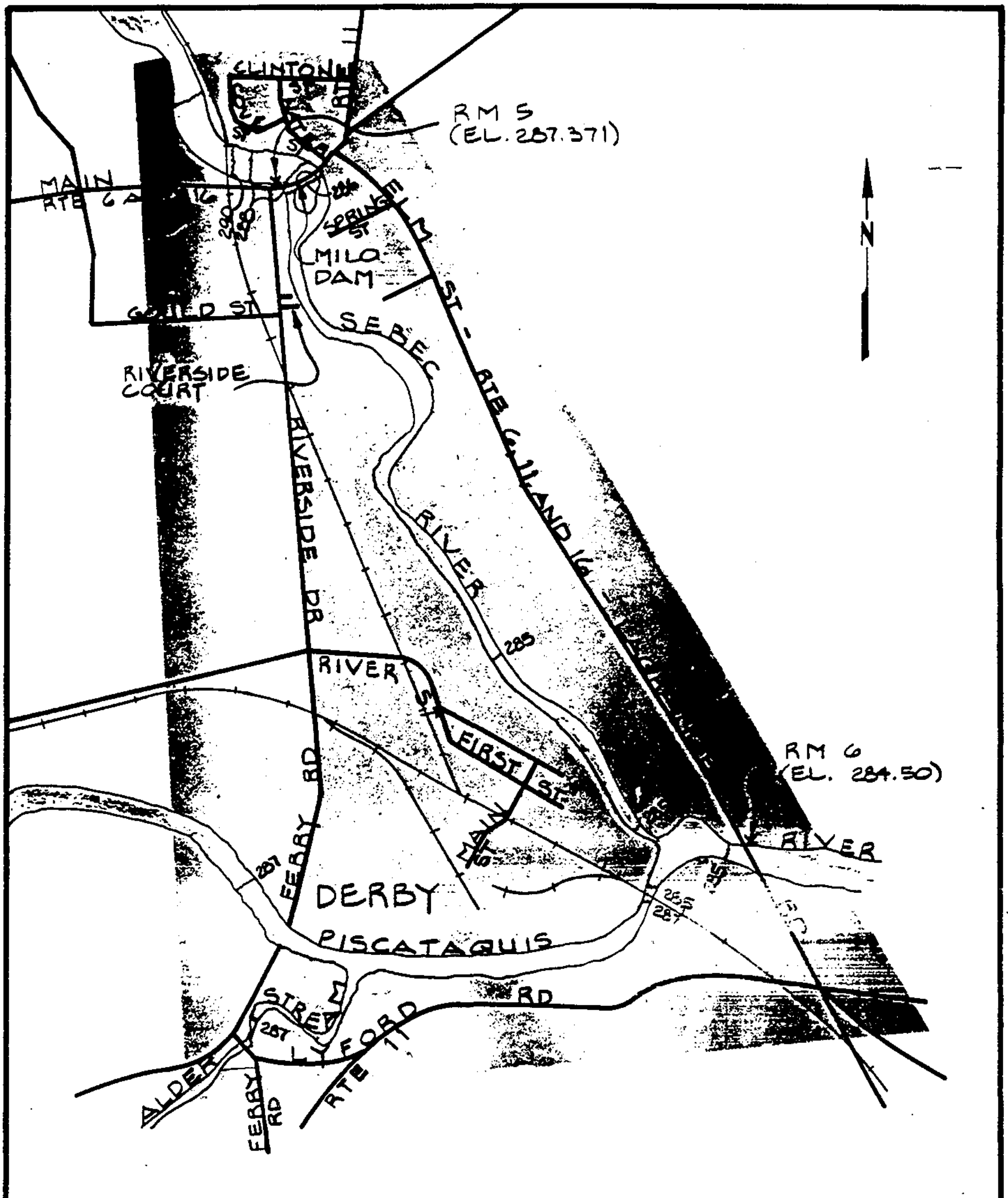
To prevent overbank flooding in the Main Street area of Milo, a structural plan consisting of possible modifications to the existing dam and construction of dikes or walls upstream of the dam was initially considered. However, hydraulic investigations determined that flooding in the Main Street area is caused partially by the Piscataquis River, which backs up the Sebec River. Consequently, this plan would not completely solve the flood problem. The cost of this plan would also be very high due to extensive riverbank development in this area. As a result of these factors, the only plans warranting further study were raising or floodproofing structures and early warning. The floodproofing alternative would include raising 22 first floors and floodproofing eight basements.

Environmental Considerations - The primary area investigated was along the south bank of the Sebec River, upstream of the dam and and Main Street. Between the dam and the upstream railroad bridge, riparian vegetation was limited to a narrow band near the riverbank Species noted include willow, red-osier, dogwood, grey birch, elm, bullrush, alder, box elder, sedges, Japanese knotweed and raspberry. Cattails and sedges occurred waterward of this vegetation. Upstream of the railroad bridge, vegetation was predominately grasses, sedges and rush. An active beaver lodge was also noted in this area. These resources would not be impacted by the nonstructural measures under study.

Economic Analysis - The costs and benefits of floodproofing or raising structures is presented below.

	First Cost	Annual Cost	Annual Benefits	Benefit Cost Ratio	Net Benefits
Floodproof or Raise Structures	$1,025,000	$92,400	$35,000	0.38	Negative

This plan of protecting individual structures was not economically justified an annual costs exceed annual benefits. The town of Milo should, however, be included in a flood warning system.



LEGEND

LIMITS OF FLOOD STUDY

MILO

PLATE 1Q

HOWLAND

Damage Centers and Alternatives Studied - Flooding in Howland occurs primarily in the center of town which is situated near the confluence of the Penobscot and Piscataquis Rivers (see Plate 11). There are 92 structures that have flood loss potential in Howland. The majority of these structures (74) are located on the north bank of the Piscataquis River in the area bordered by Main and Water Streets. The remainder (18) are located across the river on River Street.

The structural plan of flood control evaluated for Howland is an earthen dike, approximately 2400 feet long. The location of this earth dike is shown on Plate 12. This plan would provide 100-year flood protection to an area consisting of Water Street, Main Street, Valley Avenue, York Street and Davis Street. A total of 74 structures would receive flood protection. Nonstructural alternatives, including floodproofing and early warning, were also evaluated The floodproofing plan includes raising the first floors of 33 structures and floodproofing the basements of 15 other buildings.

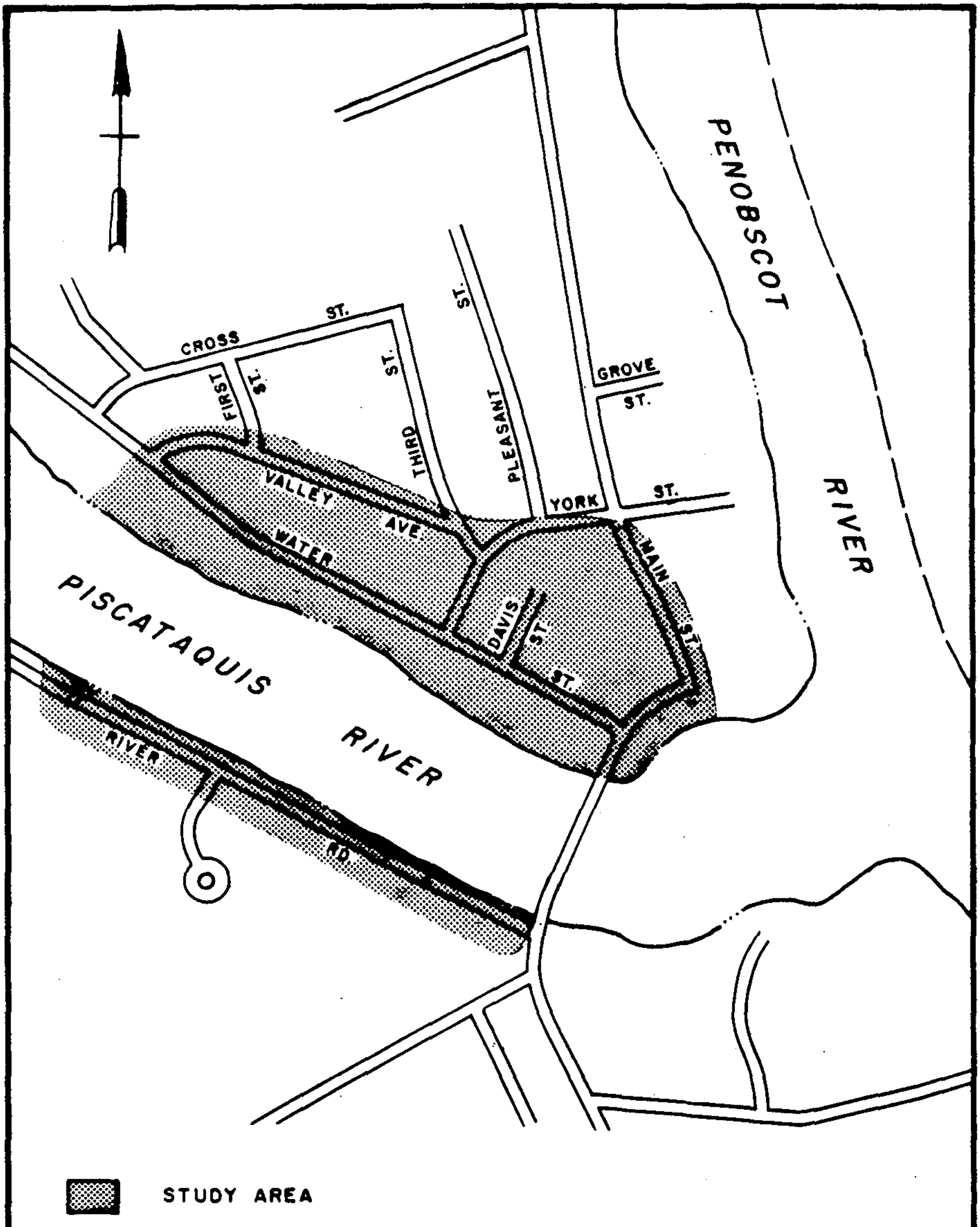
Environmental Considerations - A well-developed forested wetland exists near the upstream limit of the study area. Species noted include red maple, white pine, white birch, alder, hazel nut, green ash, silver maple, red-osier dogwood, black cherry, wild rose, grey birch, aspen, elderberry, sensitive fern, goldenrod and reed canary grass. Signs of beaver activity were noted. Downstream, riparian vegetation consists of scattered trees and shrubs near the river's edge. Species noted included white pine, red maple, white birch, black cherry, oak, elm, elderberry, raspberry, cinquefoil and buttercup. Much of the riparian zone has been developed or is disturbed. Fill has recently been placed in the river at a trailer park. Scattered stands of emergent vegetation also occur along the river. An emergent wetland exists at the downstream end of the study area. The opposite bank was vegetated by grasses, herbaceous vegetation and scattered trees and shrubs. Species noted include white pine, box elder, alder, red maple, red-osier dogwood, ash, white birch, yellow birch and Japanese knotweed.

Wetlands exist at both the upstream and downstream limits of the proposed dike. In both areas, however, it appears the wetlands could be avoided by situating protection away from the river. Impacts to riparian vegetation along the middle reach would be minimal since this area is already highly developed. Some emergent vegetation would be lost if the dike footprint were placed in the river.

Economic Analysis - The economic evaluation of the structural and nonstructural plans considered in Howland are presented below.

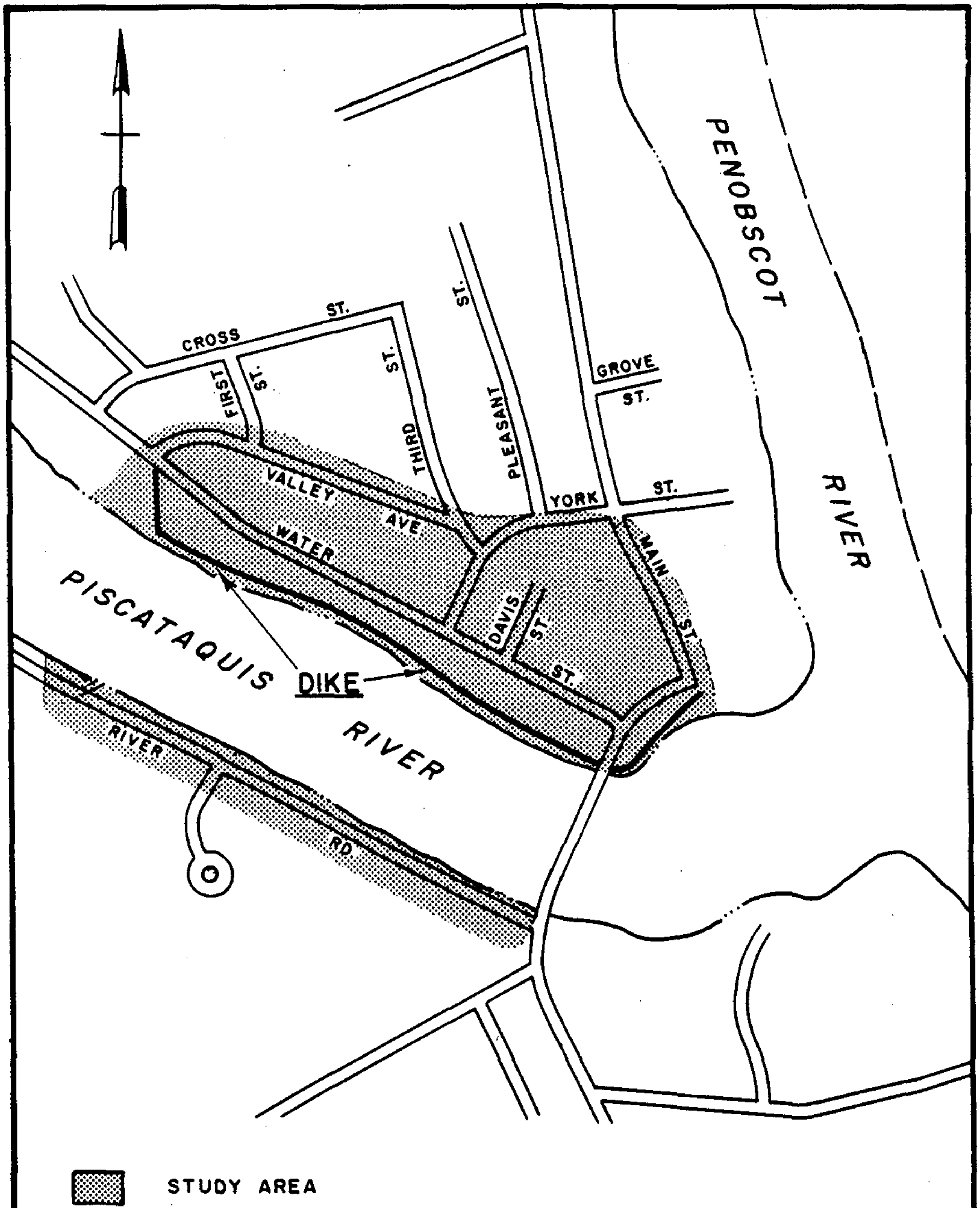
	First Cost	Annual Cost	Annual Benefits	Benefit Cost Ratio	Net Benefits
Earth Dike	$1,100,000	$99,000	$84,400	0.85	Negative
Floodproof or Raise Structures	$1,542,000	$138,800	$57,500	0.41	Negative

As shown above, protecting the primary damage area in Howland with a dike is not economically justified. In addition, the cost of providing individual protection by raising first floors or floodproofing basements was also found to exceed flood control benefits. Since implementation of these specific improvements is not warranted, Howland should be included in a regional flood warning plan.



STUDY AREAS
HOWLAND

PLATE 11



DIKE LOCATION
HOWLAND

PLATE 12

PASSADUMKEAG

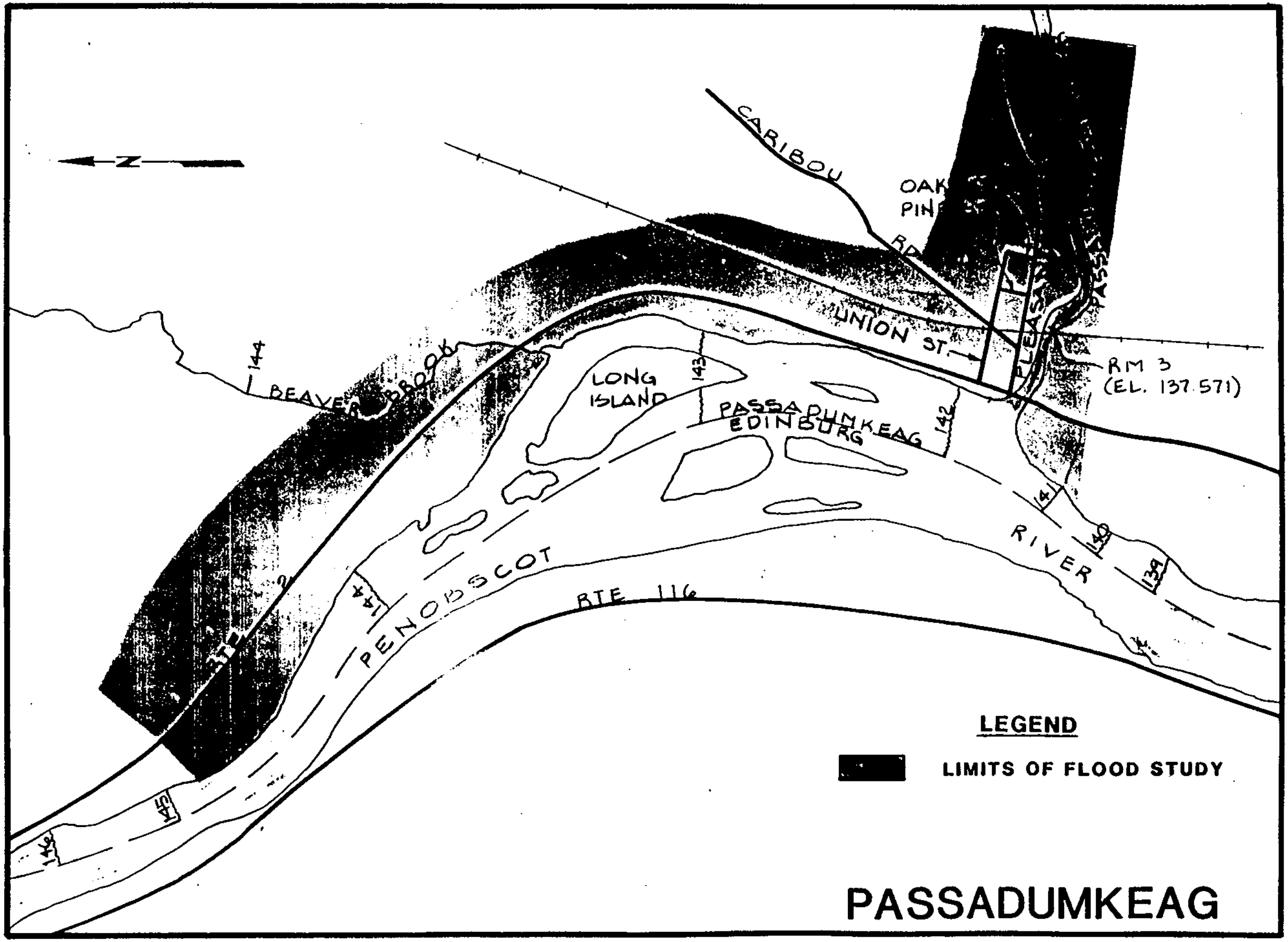
Damage Centers and Alternatives Studied - Within the area studied, a total of 42 structures have flood potential. About one-half of these buildings are located near the confluence of the Passadumkeag River and the Penobscot River. The other one-half are strung out along Route 2 north of this confluence. Alternatives initially considered included an earth dike along the Passadumkeag and Penobscot Rivers to protect this population center. However, due to the length of dike required and the relatively small number of properties receiving protection, this plan was clearly not economically justified. Further analysis of alternatives in Passadumkeag was therefore limited to nonstructural alternatives. This included raising or floodproofing and early warning. The raising and floodproofing alternative included elevating the first floors of 19 structures and installing flood shields to prevent flooding of 5 basements.

Environmental Considerations - Riparian and upland vegetation present near the confluence of the Passadumkeag and Penobscot includes ash, red oak, red maple, elm, white birch, aspen, black willow, alder, sumac, red-osier dogwood, sensitive fern, sedges, goldenrod, rose, wild cucumber and grasses. Recent beaver damage was noted. Riparian vegetation upstream from the confluence to the railroad bridge consists of a thin band of trees and shrubs growing on the river bank. In most areas along this stretch of the river, lawn extends to the riverbank. Homes are about 30 to 50 feet from the bank. Upstream of the railroad bridge, homes are well removed from the river. A low area along this reach supports a red-osier dogwood thicket and beaver lodge. It would be possible to completely avoid riparian vegetation along the upstream reach of the Passadumkeag by placing a dike well back from the river. Along the downstream reach of the Passadumkeag and along the Penobscot, impacts to riparian forest seem probable. The rare plant Lampsilis cariosa is reported to occur at the Passadumkeag study site and could be impacted by dikes or walls.

Economic Analysis - The cost and benefit analysis of the nonstructural improvement plan is as follows:

	First Cost	Annual Cost	Annual Benefits	Benefit Cost Ratio	Net Benefits
Floodproof or Raise Structures	$879,000	$79,000	$13,300	0.17	Negative

This analysis determined that nonstructural modifications to buildings in Passadumkeag are not economically justified and further study of this alternative is warranted. To reduce future damages to these areas, they should however be included in a regional warning and evacuation plan.



PASSADUMKEAG

PLATE 13

MILFORD

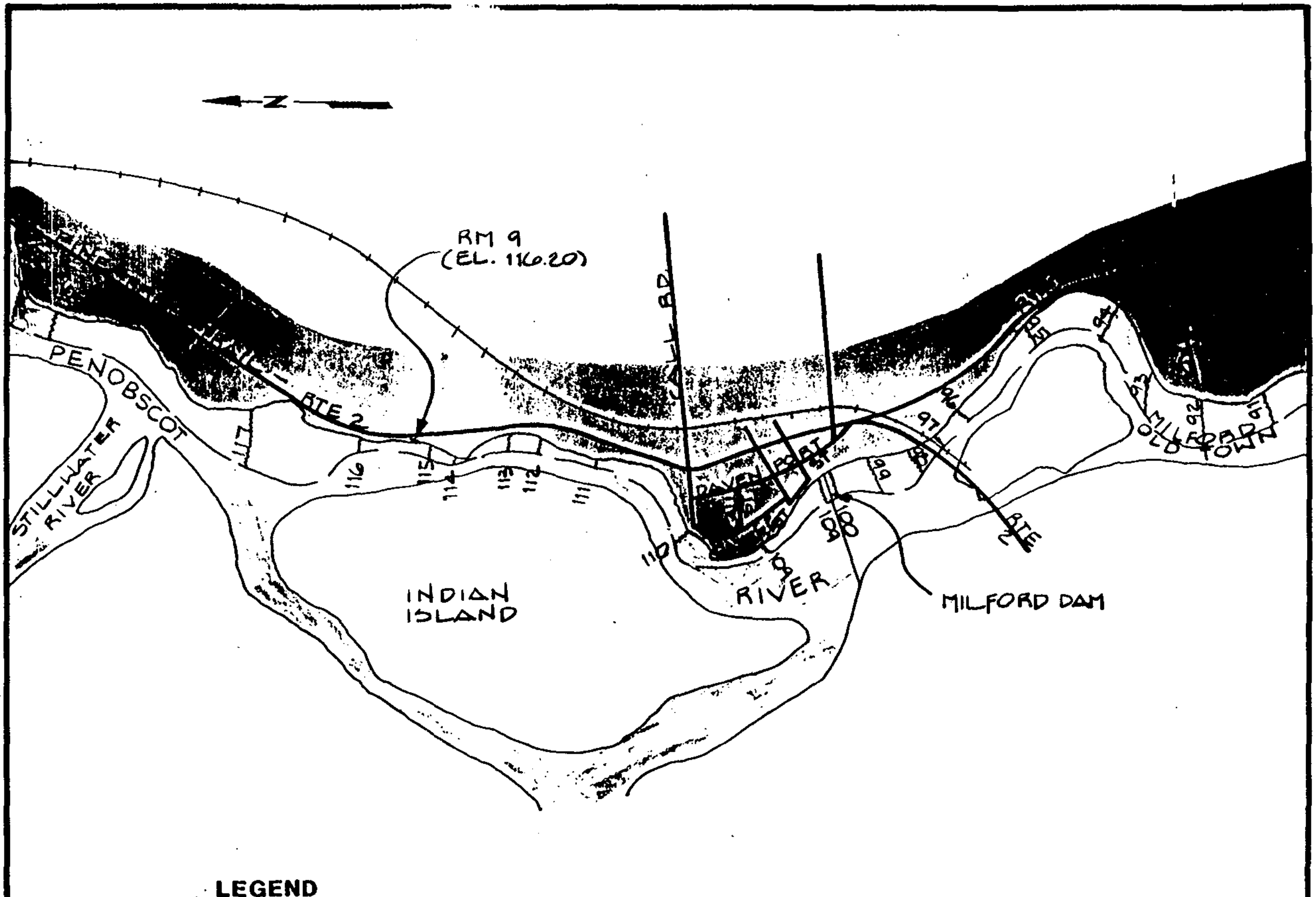
Damage Centers and Alternatives Studied - There are two major damage centers in Milford. The first is the Costigan damage zone which is the area surrounding and including the village of Costigan. This area has 67 structures susceptible to flood damage. The other damage center located downstream of this area, includes damages for the remainder of Milford. This zone encompasses 3 damage sub-centers situated along the Penobscot River. A total of 52 structures are located in this second zone. Structural solutions to flooding in these areas were considered during initial screening, but it was determined that damages were too widespread to justify the lengths of wall or dike required to effectively control flooding. Further studies were limited to raising or floodproofing property damaged by the 100-year flood and early warning and evacuation. The floodproofing plan for the Village of Costigan includes raising 52 homes and floodproofing eight basements, and the plan for the remainder of Milford calls for raising 28 first floors and floodproofing the basements of two buildings.

Environmental Considerations - In as much as nonstructural alternatives were the only plans evaluated in detail, field investigations to identify environmental resources in Milford were not conducted. Nonstructural plans are generally considered to have no impacts on riparian/aquatic habitat or fish and wildlife resources.

Economic Analysis - The following tabulation presents the costs and benefits of raising and floodproofing structures in the Village of Costigan and the remainder of Milford.

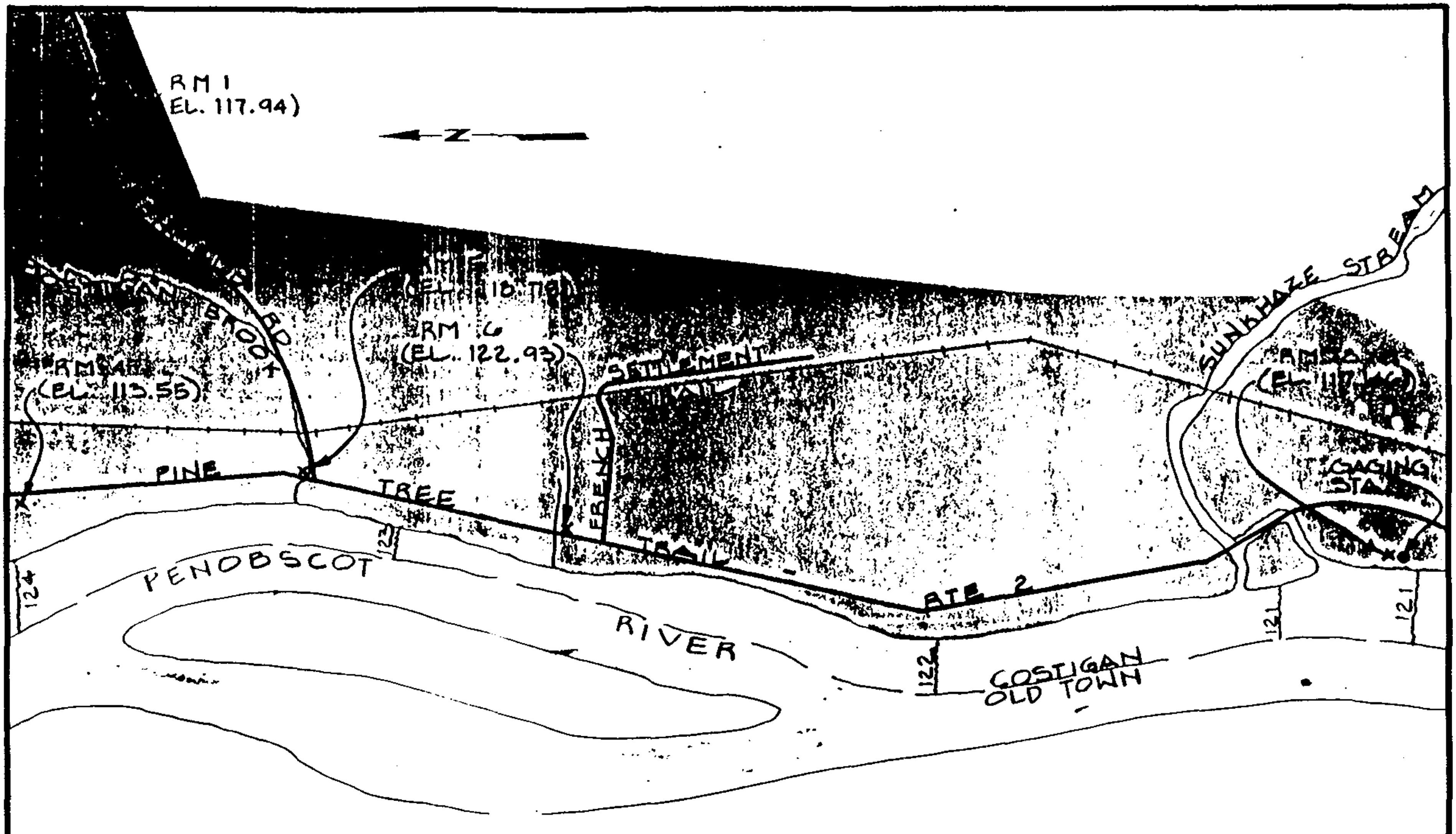
	First Cost	Annual Cost	Annual Benefits	Benefit Cost Ratio	Net Benefits
Floodproofing or Raising Structures					
Village of Costigan	$2,370,000	$213,000	$54,100	0.25	Negative
Remainder of Milford	$1,280,000	$115,600	$21,700	0.19	Negative

As determined by the above analysis, the cost of raising or floodproofing structures in Milford exceeds attributable flood control benefits, and further study is not justified. However, early warning and evacuation should be considered to reduce future flood related damages.



Z
RM 9
(EL. 116.20)
PENOBSCOT
STILLWATER RIVER
RTE 2
INDIAN ISLAND
RIVER
MILFORD DAM
MILFORD
OLD TOWN
LEGEND
LIMITS OF FLOOD STUDY

MILFORD



LEGEND

LIMITS OF FLOOD STUDY

MILFORD
(VILLAGE OF COSTIGAN)

PLATE 15

OLD TOWN

Damage Centers and Alternatives Considered - There are three damage centers in Old Town. One is located upstream of Milford Dam on Indian Island. The other centers are situated downstream of the dam; one is on the right bank of the Penobscot River along South Water and Sawyer Streets, and the other consists of low-lying portions of French Island. There are 23 structures in the Indian Island damage center of which 21 are homes and two are small commercial buildings. On French Island there are 21 residential structures subject to flooding. Flooding in the South Water Street area impacts 14 buildings.

Structural plans were not formulated for Old Town because the annual flood losses to be prevented at each damage center would not justify the high cost of required protection. Roadway modifications would be necessary at both the South Water Street and Indian Island zones and there is insufficient riverbank area for traditional structural measures at some locations on French Island. A flood control gate would also be required at the pond on Indian Island. These factors would result in high construction costs.

Consequently, studies concentrated on nonstructural measures which were both less costly and less disruptive. The Nonstructural floodproofing measures (raising first floors and installing flood shields on basements) were formulated for each of the three damage centers. These are; (1) Indian Island - nine first floor raisings and two basement floodproofings, (2) French Island - eleven first floor raisings and four basement floodproofings and (3) South Water Street - fourteen first floor raisings.

Environmental Considerations - The South Water Street site lies along the West bank of the Penobscot River between the Route 2 bridge and the Great Works Dam. The Maine Central Railroad line lies directly adjacent to the river along the upstream reach of the study site. The bank is riprapped and vegetation consists of scattered shrubs, small trees, herbaceous plants, and grasses. Species noted include cottonwood, grey birch, green ash, poison ivy, purple loosestrife, blue vervain, alder buckthorn, box elder, cottonwood, black locust, apple, alder, red maple, sugar maple, elm, red-oiser dogwood, night shade, knotweed, meadowsweet, mullein, aster, goldenrod, and grasses. Along the downstream reach, railroad tracks are set back somewhat from the river. Riparian vegetation consists of open field vegetated by grasses and forbs and a wooden area dominated by black locust, red maple, green ash, and elm.

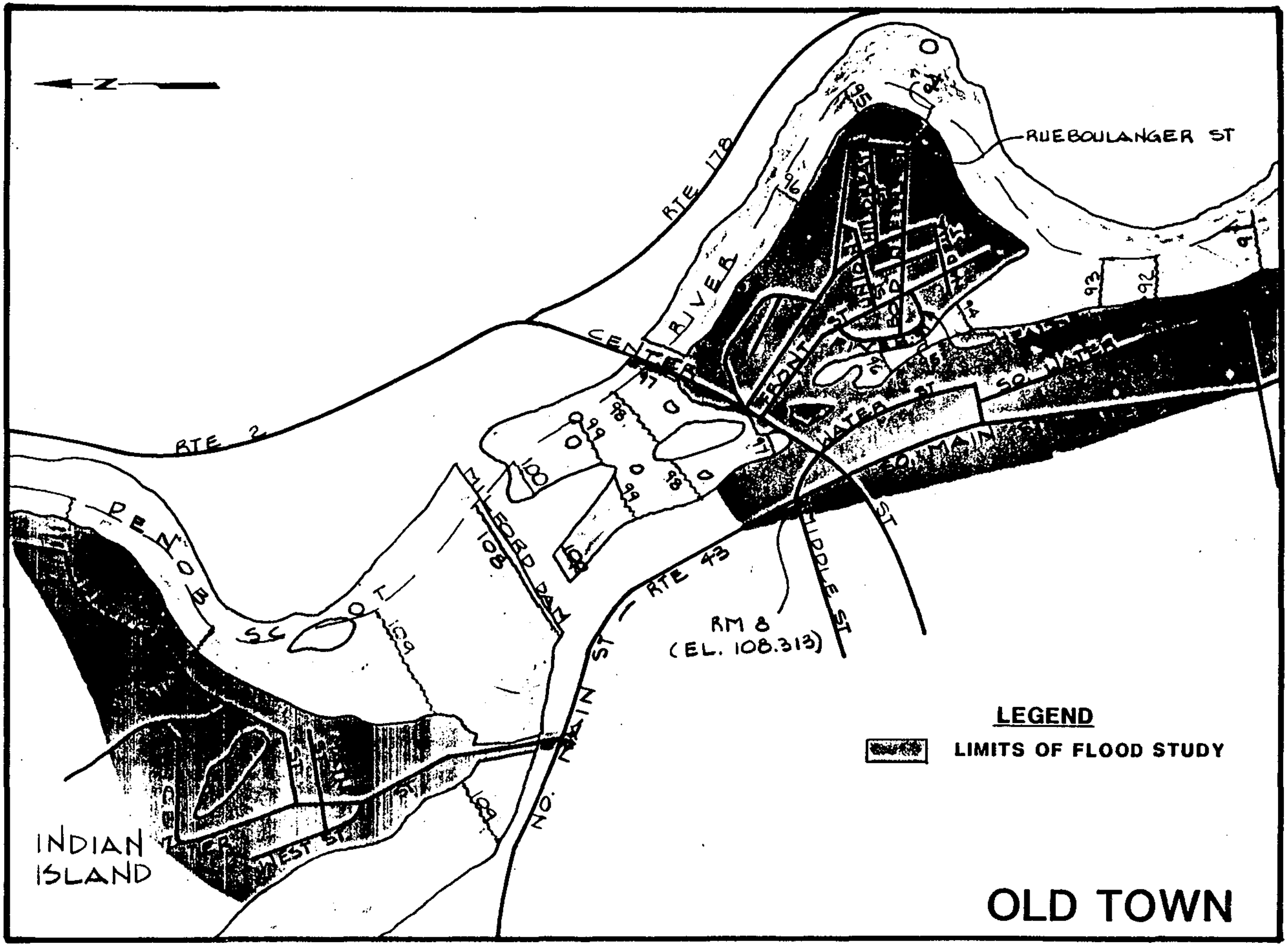
A second study site in Old Town is near a small pond on Indian Island. A narrow band of wetland vegetation occurs along the pond margin. Species noted included sweetgale, meadowsweet, broadleaf cattail, sedges, rush, goldenrod, willow, wild cucumber, and mint. The pond supports a warm water fishery for species such as pickerel, and the Penobscot Indian Nation has expressed an interest in developing some type of fish culture project. Waterfowl and herons reportedly utilize the pond.

Construction of a dike or wall along South Water Street would destroy some aquatic habitat. Impacts to riparian habitat along this section would be minimal, since existing vegetation is sparse and the embankment has been riprapped. A flood control gate and road modifications at the pond on Indian Island would probably have only minor construction related impacts. To minimize long term impacts the gate should only be operated during periods of high water.

Economic Analysis - The economic analysis nonstructural plans investigated in Old Town are presented below:

	First Cost	Annual Cost	Annual Benefits	Benefit Cost Ratio	Net Benefits
Floodproofing or Raising Structures					
Indian Island	$415,000	$37,400	$12,700	0.34	Negative
French Island	$512,000	$46,100	$18,100	0.39	Negative
South Water Street	$638,000	$57,500	$31,500	0.55	Negative

Since the benefit cost ratio of these plans is less than unity further study is not economically justified. Future flood damage could be reduced by issuing flood warnings and evacuating these areas.



N
RUEBOULANGER ST
RTE 178
RIVER
CENTER
FRONT ST
WATER ST
SO. WATER
SO. MAIN
MIDDLE ST
ST
RTE 2
MILFORD DAM
RTE 43
NO. MAIN ST
RM 8
(EL. 108.313)
PENOBSCOT
WEST ST
INDIAN
ISLAND
LEGEND
LIMITS OF FLOOD STUDY
OLD TOWN

PLATE 16

BRADLEY

Damage Centers and Alternatives Studied - There are two separate damage centers in Bradley. The larger, containing 42 flood prone structures, is located along Main Street upstream of the confluence of the Penobscot River and Otter Brook. The smaller area, consisting of seven structures, is situated along Elm Street immediately downstream of this confluence. See Plate 17 for the location of these areas. Structural improvements, consisting of a 2600 foot long earth dike and appurtenant structures were evaluated to protect the Main Street damage center from a 100-year flood. The dike, shown on Plate 18, would extend southerly along the east bank of the Penobscot River and then easterly and northerly along Otter Brook. A nonstructural plan consisting of raising the first floors of 30 structures and floodproofing the basements of nine other buildings was also considered. This nonstructural plan would provide protection to low lying structures in both damage centers.

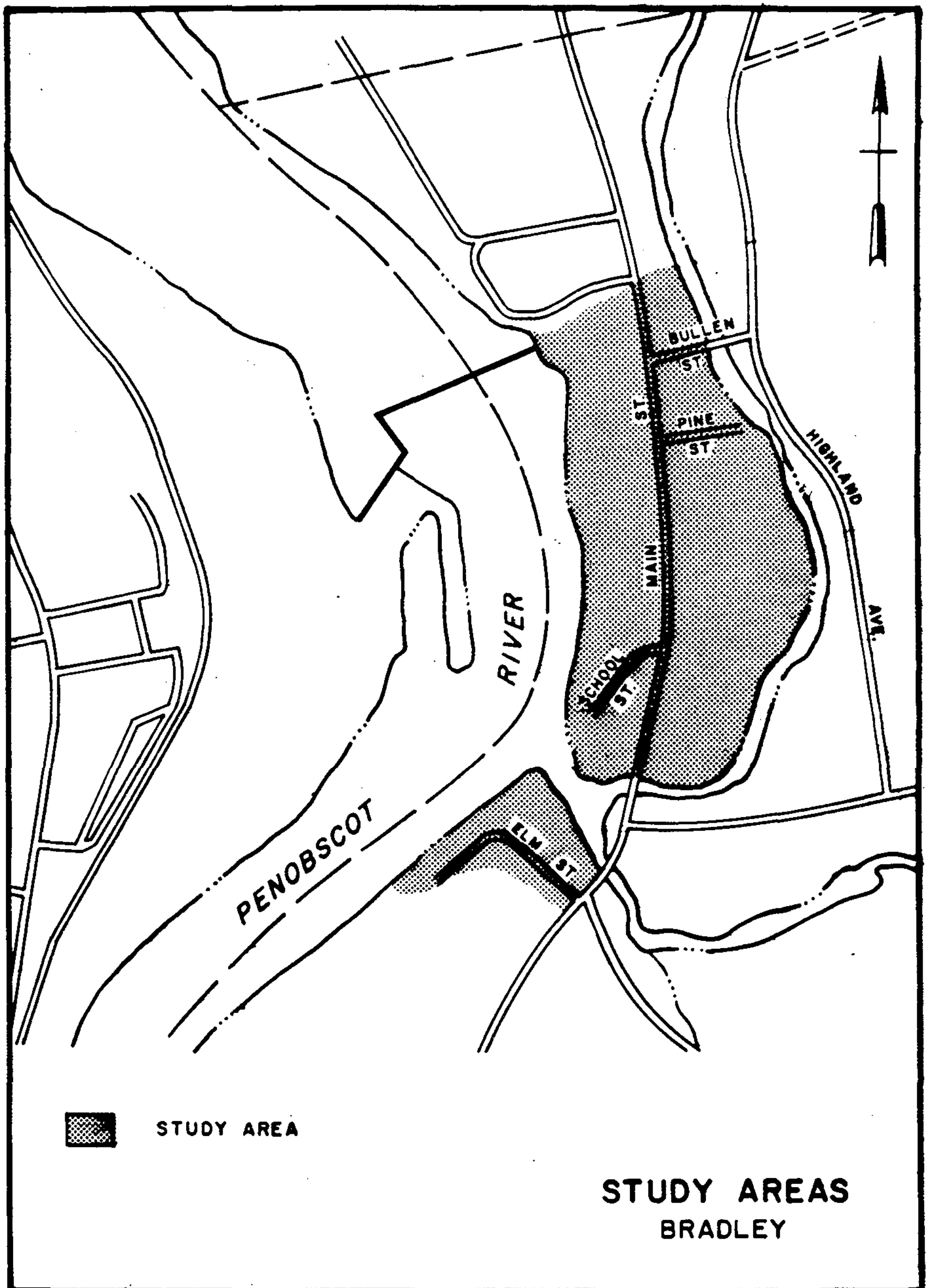
Environmental Considerations - The main study site extends 2000 feet downstream along the east bank of the Penobscot from below the Great Works Dam to the confluence with Otter Stream, and 2000 feet upstream along the north bank of Otter Stream to the Bullen Street bridge. A broad, forested wetland occurs along most of Otter Stream. Species noted included box elder, black cherry, cottonwood, oak, red maple, red-oiser dogwood, alder, elm, ash, apple, hawthorne, elderberry, wild rose, raspberry, sensitive fern, wild cucumber, aster, goldenrod, reed canary grass, and unidentified grasses. There is a substantial amount of standing and fallen dead wood present to provide habitat for cavity nesting birds and mammals. Dense thickets of hawthorne and apple also offer good food and cover value for wildlife. Part of the riparian zone is mowed, and appears to have been filled to establish a low dike. Emergent vegetation noted growing in the stream included bullrush, rush, broadleaf cattails, grasses, blue vervain, and purple loosestrife. The emergent community was best developed in a broad area just upstream of the Route 178 bridge. Upstream of this area Otter Stream narrows considerably, and supports only scattered emergent vegetation. Mallards were observed feeding among wetland vegetation in the stream. Along the Penobscot, the study site consists primarily of forested wetlands with species composition similar to that along Otter Stream. An old field occurs near the confluence of the Penobscot with Otter Stream.

Along most of Otter Stream there appears to be ample room to avoid entirely or minimize impacts to existing riprarian or emergent vegetation. Some wetlands would be impacted by a dike upstream, near the Bullen Street bridge where homes are close to the stream. Protection along the Penobscot would impact a high quality riparian forest.

Economic Analysis - The costs and benefits associated with the structural and nonstructural plans considered in Bradley are presented below.

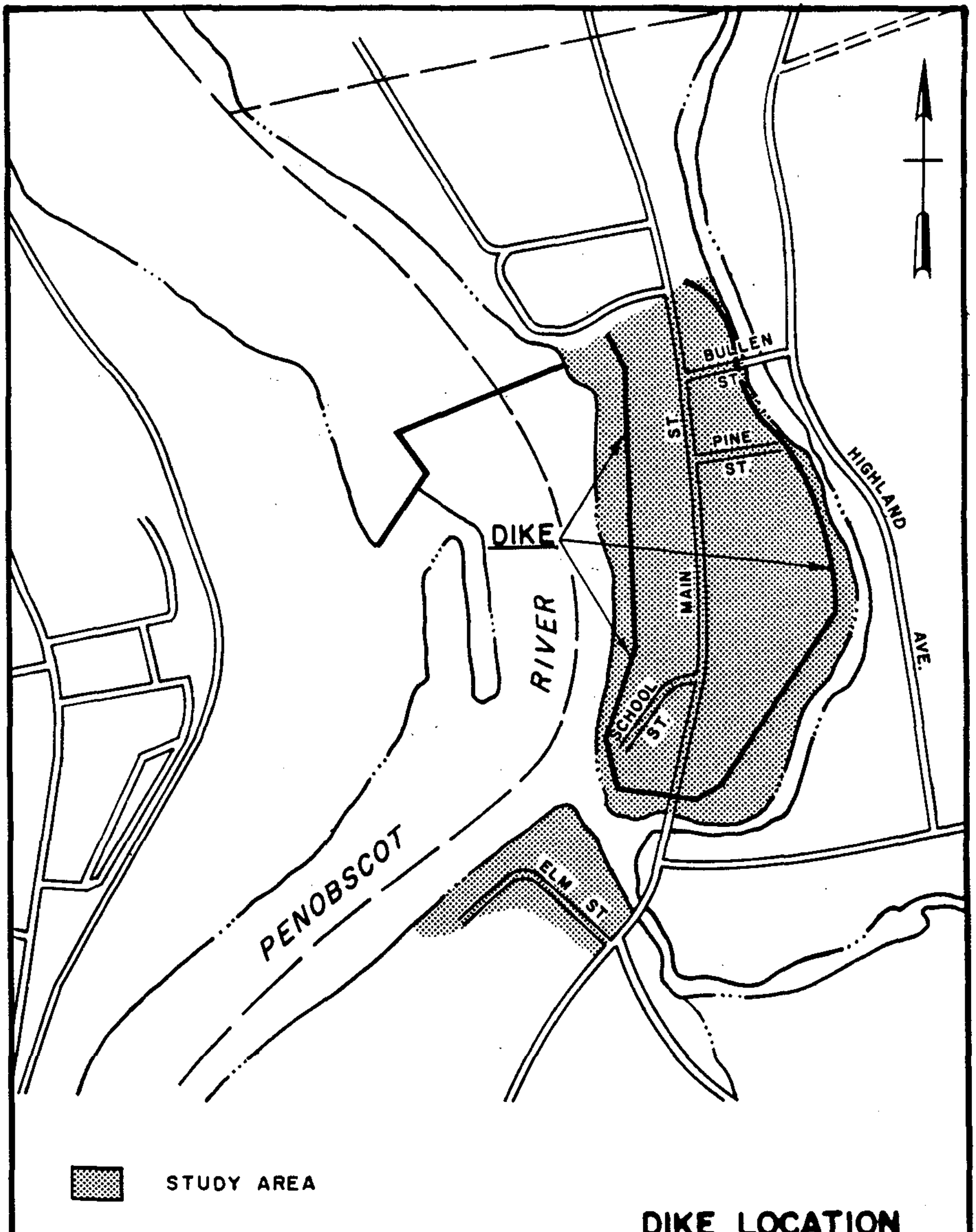
	First Cost	Annual Cost	Annual Benefits	Benefit Cost Ratio	Net Benefits
Earth Dike	$1,140,000	$102,600	$51,100	0.50	Negative
Floodproof or Raise Structures	$1,390,000	$125,300	$50,000	0.40	Negative

As shown in the above table, flood control benefits are insufficient to justify the cost of providing protection in the Bradley study areas. However, implementation of an early warning and evacuation plan should be considered to reduce future flood impacts.



STUDY AREAS
BRADLEY

PLATE 17



DIKE LOCATION
BRADLEY

PLATE 18

ORONO

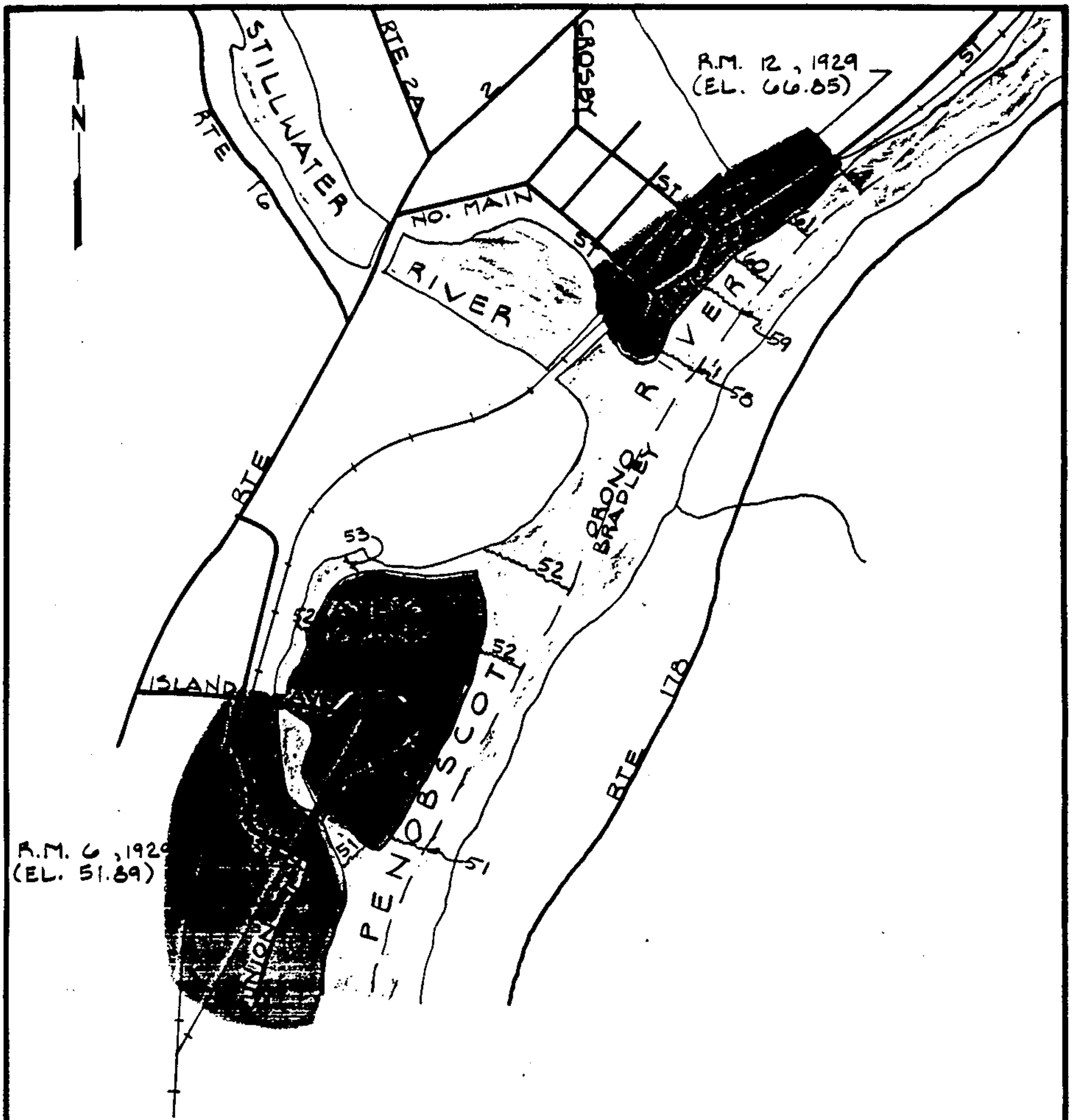
Damage Center and Alternatives Considered - Two areas of Orono were investigated to determine the extent of potential flood damage. Plate 19 shows the location of these areas. The first area was situated upstream of the confluence of the Penobscot and Stillwater Rivers along Central Penobscot Street. This area was eliminated early in the study as field investigations determined that flooding was very limited in this area. The second area is located downstream of the mouth of the the Stillwater River. It has 27 structures within the floodplain; 19 of which are residential, one is commercial and seven are industrial. These structures are located primarily along South Penobscot street and on Ayers Island. Due to the low amount of annual flood losses in this area, structural plans of improvement were not formulated as economic justification was highly doubtful. The nonstructural plan evaluated for Orono included raising the first floor of eight structures, floodproofing the basements of four buildings, and floodproofing the first floor of another building.

Environmental Considerations - The main study site is along the west bank of the side channel of the Penobscot that flows around Ayers island. The site extends about 1500 feet along South Penobscot and Union Streets. The riverbank along the project area is forested. Species noted include grey birch, ash, willow, elm, oak, silver maple, red maple, sugar maple, red-oiser dogwood, a Viburnum, purple loosestrife, wild cucumber, and goldenrod. Riparian vegetation is bordered by lawns and, at the downstream extreme of the project area, an old field overgrown with Japanese knotweed. A well developed emergent community is present in the river. Species noted included loosestrife and unidentified grasses and sedges. Beaver sign was noted throughout the site. Any dike construction along the riverbank in this area would probably impact a narrow bank riparian forest situated between residential development and the river.

Economic Analysis - The following tabulation shows the costs and potential benefits of providing nonstructural improvements at the second damage center in Orono.

	First Cost	Annual Cost	Annual Benefits	Benefit Cost Ratio	Net Benefits
Floodproof or Raise Structures	$396,000	$35,700	$8,000	0.22	Negative

Although nonstructural flood control improvements are not economically justified, an early warning system would mitigate future flood losses.



LEGEND

LIMITS OF FLOOD STUDY

ORONO

EDDINGTON

Damage Center and Alternatives Considered - Investigations in Eddington determined that only four structures had flood loss potential in the study area. Losses in this area, shown on Plate 20, are limited to two residences on Bradley Road, and a convenience store and sportsman's club on North Main Street. One structure has its first floor at the 100 year flood level while the others are above this elevation. Structural plans were not formulated due to the minimal level of expected annual losses. Since only one structure would sustain appreciable damage from a 100-year flood, the evaluated nonstructural plan was limited to the raising of the first floor of one structure.

Environmental Considerations - In as much as only nonstructural options were under consideration at this site, no analysis of environmental resources was conducted.

Economical Analysis - The analysis of the feasibility of raising the one structure susceptible to 100-year flooding is presented below:

	First Cost	Annual Cost	Annual Benefits	Benefit Cost Ratio	Net Benefits
Raise Structure	$45,600	$4,100	$100	0.02	Negative

This plan is clearly not economically justified. Although the potential for flood loss from the Penobscot River is limited in Eddington, a flood warning system would still be beneficial in this area.

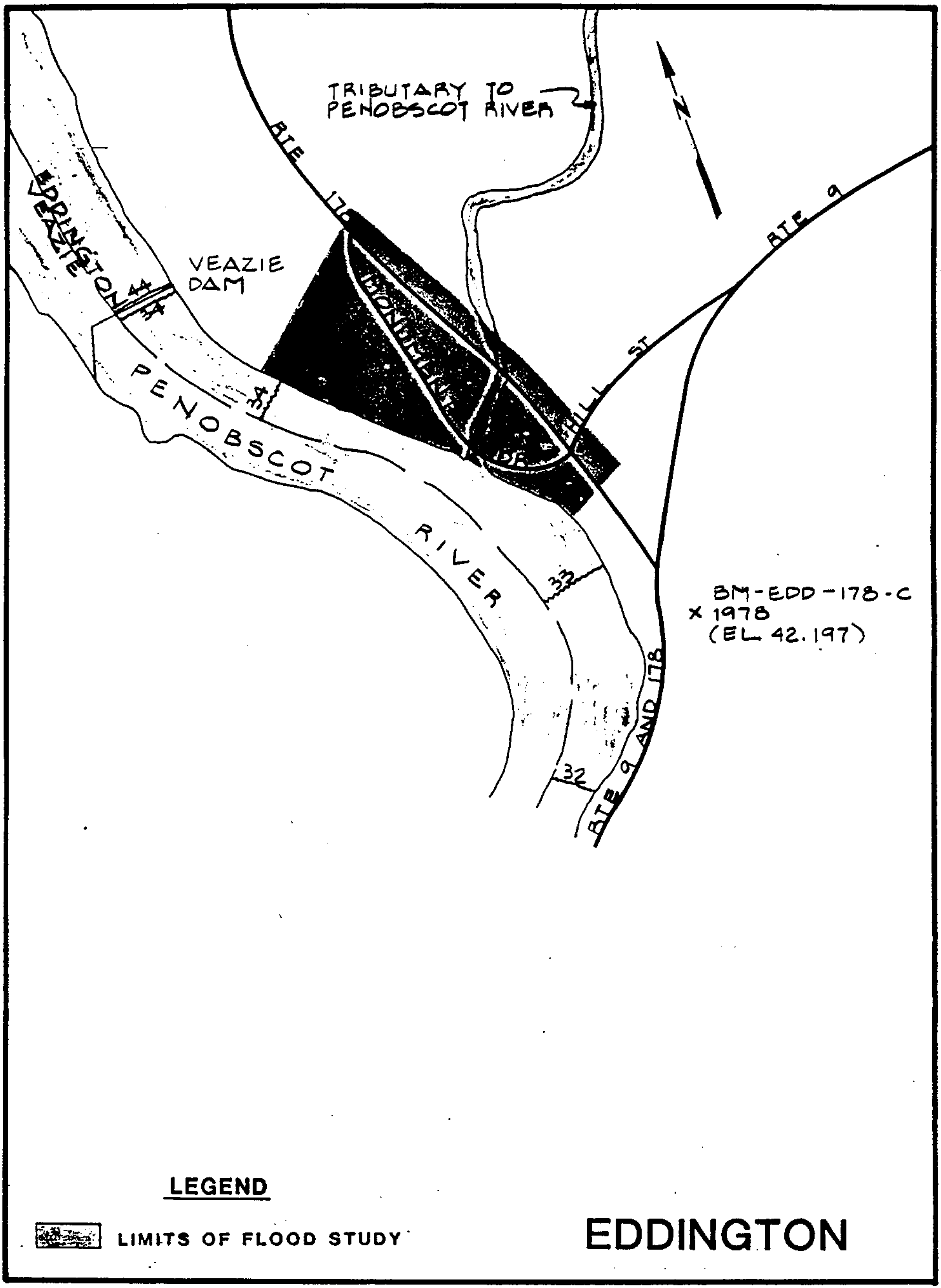

TRIBUTARY TO PENOBSCOT RIVER
N
RTE 178
RTE 9
EDDINGTON
VEAZIE
VEAZIE DAM
44
34
MONUMENT DR
MILL ST
PENOBSCOT RIVER
33
32
BM-EDD-178-C
× 1978
(EL 42.197)
RTE 9 AND 178
LEGEND
LIMITS OF FLOOD STUDY
EDDINGTON

PLATE 20

BREWER

Damage Center and Alternatives Considered - The damage center evaluated in Brewer is situated along the east bank of the Penobscot River upstream of Felts Brook and the Bangor Water Works Dam (See Plate 21). This damage area consists of 49 structures, all located on North Main Street adjacent to the Penobscot River. The majority of the structures are residential (44), and the remainder are commercial (4) and public (1). The frequency of flooding in this area has changed in recent years due to the partial breaching of the Bangor Water Works Dam. As a result, only eight structures have first floor flood damage during a 100-year flood. Structural plans of protection were not formulated because of the low level of expected losses per structure and the linear dispersion of buildings. In addition, the proximity of some structures to the river would result in high dike or wall costs. The nonstructural plan formulated for this area includes raising the first floors of eight buildings and floodproofing the basements of six other buildings.

Environmental Considerations - Within the study area a narrow band of riparian vegetation exists along the Penobscot River. The remainder of the floodplain consists of cleared areas and lawns. Species noted along the edge of the river include box elder, ash, willow and Japanese knotweed.

Economic Analysis - The costs and benefits of modifying structures to reduce flooding in Brewer are shown below.

	First Cost	Annual Cost	Annual Benefits	Benefit Cost Ratio	Net Benefits
Floodproofing or Raising Structures	$378,000	$34,000	$17,000	0.50	Negative

In as much as the cost of modifying structures exceeds flood control benefits, further evaluation of this alternative is not warranted. However, early warning and evacuation should be considered as a damage reduction measure.

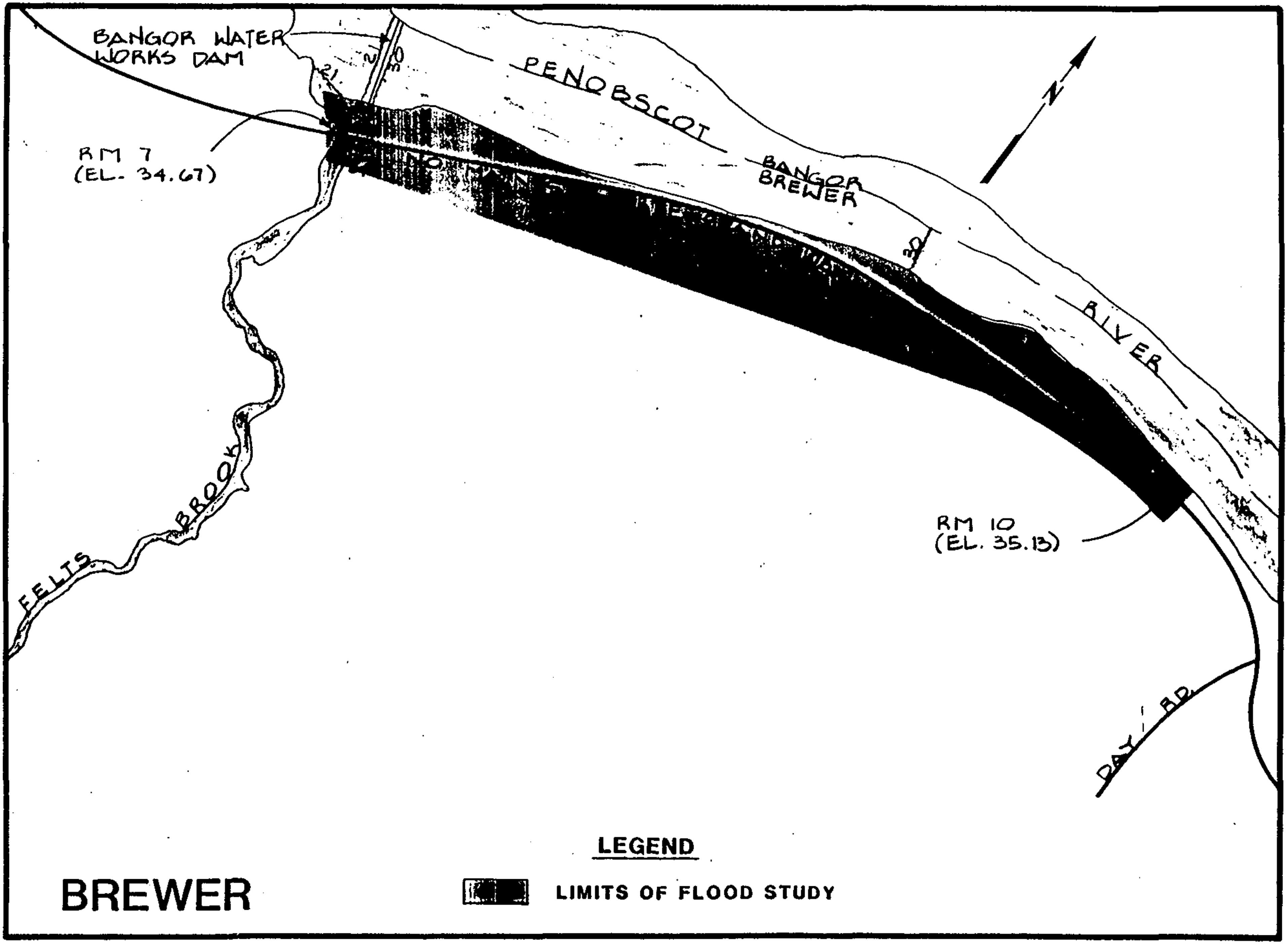

BANGOR WATER WORKS DAM
PENOBSCOT
BANGOR
BREWER
RIVER
RM 7
(EL. 34.67)
RM 10
(EL. 35.13)
FELTS BROOK
DAY RD.
21
30
LEGEND
LIMITS OF FLOOD STUDY
BREWER

PLATE 21

BANGOR

Damage Center and Alternatives Considered - This damage center is situated in downtown Bangor along Kenduskeag Stream. As shown on Plate 21, the area extends along both sides of the stream from its confluence with the Penobscot River upstream to Central Street. Within this area 14 commercial buildings and eight other commercial structures. Twelve of these buildings have low water entry points from one to six feet below the 100-year flood elevation. Only one, however, is subject to first floor flooding while remainder would suffer basement flooding. A structural plan of improvement was not formulated due to the relatively low level of annual losses and the geographic dispersion of buildings. Congested development conditions in much of the area would also make structural improvements more difficult to construct and therefore more expensive. Since all of the buildings are of masonry construction and most are multi-story, the only nonstructural plan is to floodproof the basements of ten buildings and the first floor of one other.

Environmental Considerations - Within the study area, Kenduskeag Stream is channelized and offers little wildlife habitat value. Riparian vegetation is limited to ornamental trees and shrubs planted at the base of walls lining the channel. The stream channel between Franklin and State Streets is bisected by a grassy strip of land maintained as a public park. Areas adjacent to the Kenduskeag channel are developed with buildings, lawns and parking lots.

Economic Analysis - The costs and benefits of floodproofing structures to prevent damage from a 100-year flood are presented below:

	First Cost	Annual Cost	Annual Benefits	Benefit Cost Ratio	Net Benefits
Floodproofing	$180,000	$16,200	$ 8,300	0.51	Negative

As demonstrated in the above analysis floodproofing structures along Kenduskeag Stream is not justified economically. However, it is suggested that owners of these properties relocate damageable property from basement areas similar to what has or is being accomplished at Fleet Bank and Merchants Bank. In addition an early warning system would reduce future flood damages in this area.

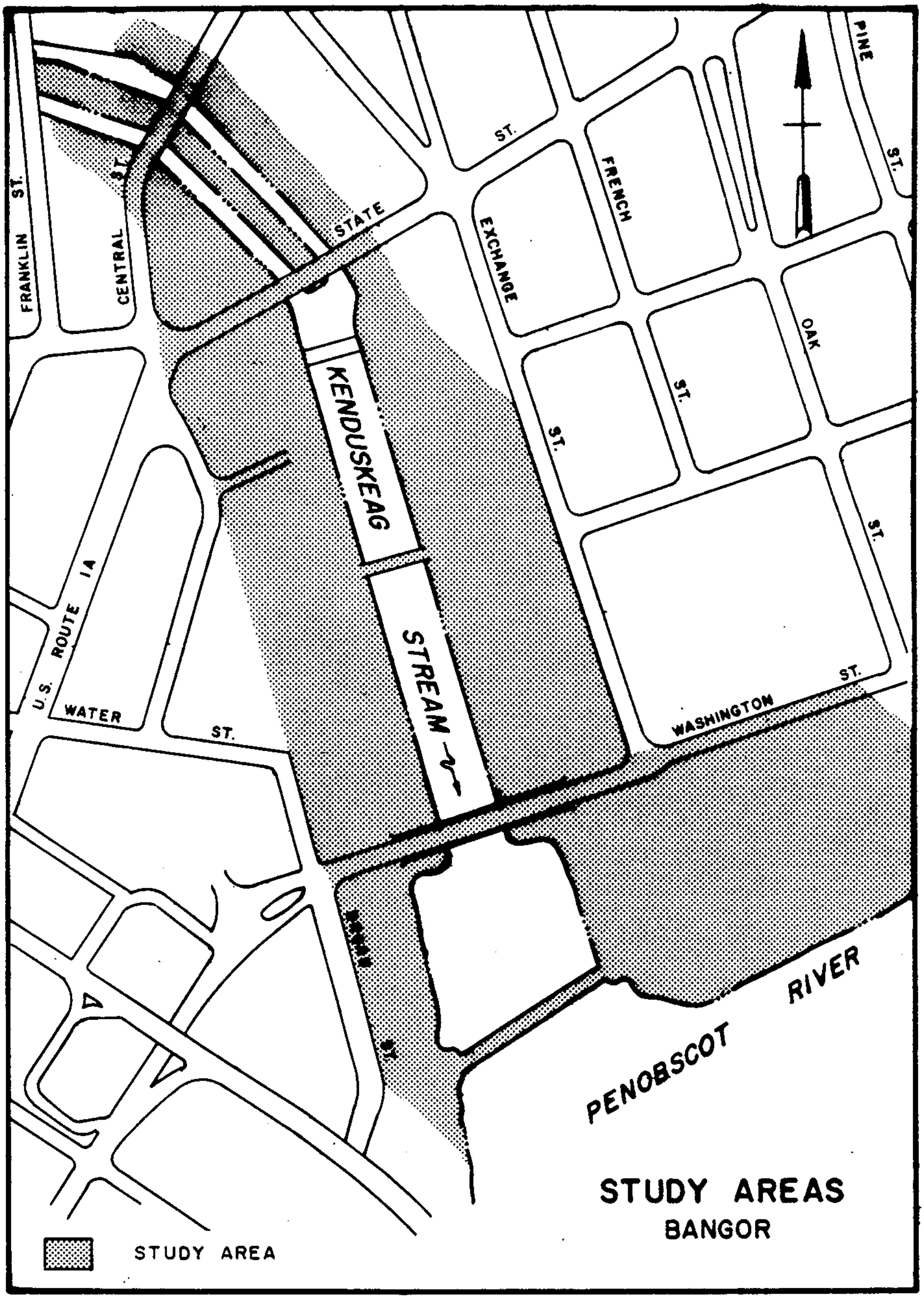

FRANKLIN ST.
CENTRAL ST.
STATE
ST.
EXCHANGE
ST.
FRENCH
ST.
PINE
ST.
OAK
ST.
KENDUSKEAG
STREAM
U.S. ROUTE 1A
WATER
ST.
WASHINGTON
ST.
ST.
PENOBSCOT RIVER
STUDY AREAS
BANGOR
STUDY AREA

PLATE 22

SUMMARY OF COMMUNITY STUDIES

A summary of the structural local protection projects and localized nonstructural projects considered in the thirteen communities studied is shown in Table 6.

As shown in Table 6, localized flood control measures, either structural or nonstructural, were not economically justified in any of the damage centers selected for study. However, as studies progressed it became obvious that damages in these communities could be reduced by installation of a regional or basin-wide flood warning system. The following section evaluates the cost effectiveness of installing an automated flood warning system.

TABLE 6
Summary of Evaluated Plans

Community	First Cost	Annual Cost	Annual Benefits	Benefit Cost Ratio
Abbot				
Nonstrucural	$ 48,100	$ 4,300	$ 200	0.05
Guilford				
Modify Dam & Wall	$1,420,000	$127,800	$18,100	0.14
Nonstructural (above dam)	$ 246,000	$ 22,100	$ 6,600	0.30
Nonstructural (below dam)	$1,380,000	$124,200	$41,900	0.34
Dover-Foxcroft				
Dike & Wall	$ 330,000	$ 29,700	$ 4,400	0.15
Nonstructural (above E. Main St.)	$ 456,000	$ 41,100	$ 4,100	0.10
Nonstructural (below E. Main St.)	$ 186,000	$ 16,700	$ 3,600	0.22
Milo				
Nonstructural	$1,025,000	$ 92,400	$35,000	0.38
Howland				
Dike	$1,100,000	$ 99,400	$84,400	0.85
Nonstructural	$1,542,000	$138,800	$57,500	0.41
Passadumkeag				
Nonstructural	$ 879,000	$ 79,000	$13,300	0.17
Milford				
Nonstructural (Costigan)	$2,370,000	$213,000	$54,100	0.25
Nonstructual (Remainder of Milford)	$1,280,000	$115,600	$21,700	0.19
Old Town				
Nonstructural (Indian Island)	$ 415,000	$37,400	$12,700	0.34
Nonstructural (French Island)	$ 512,000	$46,100	$18,100	0.39
Nonstructural (S. Water St.)	$ 638,000	$57,500	$31,500	0.55
Bradley				
Dike	$1,140,000	$102,600	$51,000	0.50
Nonstructural	$1,390,000	$125,300	$50,000	0.40
Orono				
Nonstructural	$ 396,000	$35,700	$8,000	0.22
Eddington				
Nonstructural	$ 45,600	$ 4,100	$ 100	0.02
Brewer				
Nonstructural	$ 378,000	$34,000	$17,000	0.50
Bangor				
Nonstructural	$ 180,000	$16,200	$ 8,300	0.51

AUTOMATED FLOOD WARNING SYSTEM

An automated flood warning system consists of a series of precipitation, stream flow and lake level gages located at selected points within the basin. Information concerning rainfall, stream flow and lake levels is collected at these sites and transmitted to a centralized computer. Based on this information and data concerning runoff characteristics of the basin, predictions concerning expected flood heights can be made. Information concerning estimated flood levels and time of peak stage can then be provided to individual communities in the Basin. Although flood warning does not prevent flooding, proper distribution of warnings can reduce flood damages and possible loss of lives.

Flood control benefits which accrue to an automated flood warning system are based on the relationship between forecast lead time and the associated reduction in damages. The underlying assumption is that upon receipt of the flood warning, individuals will take appropriate steps to reduce potential damages. Since this is a reconnaissance level study, an existing relationship, in the form of a curve, between forecast lead time and percent reduction in damages was employed. The relationship from Day et al (1969) was used in the 1984 Passaic River Basin Study, New York and New Jersey, and appears to be appropriate for the purposes of this study. The maximum forecast lead time from Day is 48 hours and the corresponding maximum percent reduction in damages is 35 percent. For the towns in the Penobscot Basin the estimated forecast lead times are: 24 hours - Passadumkeag, Costigan, Milford, Old Town, Bradley, Orono, Eddington, Bangor and Brewer; 18 hours - Howland; 12 hours - Abbot, Guilford, Dover/Foxcroft and Milo. Table 7 lists flood warning benefits to each of the study area communities based on annual losses and forecast lead time from the Day relationship.

TABLE 7

Flood Warning System Flood Control Benefits

Community	Benefits
Abbot	$ 100
Guilford	$14,500
Dover-Foxcroft	$ 2,800
Milo	$11,100
Howland	$25,100
Passadumkeag	$ 9,900
Milford	$31,700
Old Town	$33,200
Bradley	$19,600
Orono	$ 4,200
Eddington	$ 300
Brewer	$ 7,800
Bangor	$ 6,100
TOTAL	$166,400

The first cost of an automated flood forecasting and warning system is shown in Table 8.

TABLE 8

First cost - Automated Flood Warning System

Component	Quantity	Cost
Precipitation Gages	32	$256,000
Stream Flow Gages	11	55,000
Lake Level Gages	5	25,000
Computers	4	80,000
Communications (Repeaters)	6	48,000
SUBTOTAL		$464,000
Contingencies (10%)		$ 46,000
SUBTOTAL		$510,000
Engineering and Design (20%)		$102,000
TOTAL		$612,000

The economic analysis of the automated flood warning system is shown below. Annual costs are based on a project life of 15 years and include $51,000 in annual operation and maintenance costs.

	First Cost	Annual Cost	Annual Benefits	Benefit Cost Ratio	Net Benefits
Flood Warning System	$612,000	$126,400	$166,400	1.32	$40,000

Since annual benefits exceed annual costs, further study of an automated flood warning system is economically justified and further Federal assistance is warranted.

SECTION IV

FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

Findings and Conclusions

During the evaluation of flood problems in the Penobscot River Basin, all potentially feasible solutions to flood problems at identified damage centers were evaluated. This included upstream reservoirs, localized structural or nonstructural projects and flood forecasting and warning. These investigations determined that flood forecasting and warning was the only economically justified flood damage reduction measure. This alternative is also supported by the non-Federal Sponsor, the State of Maine. Accordingly, there is a Federal interest in pursuing further investigation of this warning system.

The total estimated first cost of an automated flood forecast and warning system is $612,000 and the benefit to cost ratio is 1.32. Inasmuch as the estimated Federal portion of the first cost of project implementation is well within the $5 million dollar Federal limit of Section 205 of the 1948 Flood Control Act, as amended, it is concluded that further study of this system could be conducted under this authority.

It is also recommended that Penobscot River Basin communities remain alert to the flood damage potential in the basin. Information contained in this report, including technical data presented in Appendices A thru E, should prove useful to these communities.

RECOMMENDATIONS

The results of the study indicated that further investigations could be accomplished under the existing Continuing Authorities Program I therefore recommend that no further work be conducted in the Penobscot River Basin under this General Investigation Study Authority.

28 June 89
Date

for DANIEL M. WILSON
Colonel, Corps of Engineers
Division Engineer

ACKNOWLEDGMENTS

This report was prepared by Richard W. Heidebrecht, Project Manager; under the supervision of Peter E. Jackson, Chief Comprehensive River Basin Section; Donald W. Martin, Chief, Basin Management Branch; and Joseph L. Ignazio, Chief, Planning Division. Others who contributed to this report include the following:

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David Keddell - Economic Analysis

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Cheryl Baer - Word Processing

Kristin Meader - Word Processing

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Thomas Marcotte

Individuals representing other Federal agencies were also consulted during this study, including the following:

Michael Tehan - U.S. Fish and Wildlife Service

Todd Mendell - National Weather Service

Appendix A

Hydrologic Reconnaissance

for

Flood Control

PENOBSCOT RIVER, MAINE

HYDROLOGIC RECONNAISSANCE

FOR

FLOOD CONTROL

BY

HYDROLOGIC ENGINEERING SECTION

WATER CONTROL BRANCH

ENGINEERING DIVISION

DEPARTMENT OF THE ARMY

NEW ENGLAND DIVISION, CORPS OF ENGINEERS

JUNE 1989

PENOBSCOT RIVER, MAINE
HYDROLOGIC RECONNAISSANCE
FOR
FLOOD CONTROL

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HYDROLOGIC RECONNAISSANCE

for

FLOOD CONTROL

PENOBSCOT RIVER, MAINE

1. PURPOSE

This report presents a review and analysis of the hydrology of floods within the Penobscot River basin. Included are sections on basin description, climatology, flood history, discharge frequencies, stage-frequency data, analysis of floods and flood control alternatives. This work was performed under the authority set forth in the U.S. Senate Resolution dated 12 November 1987, as amended.

2. REFERENCES

a. New England-New York Inter-Agency Committee, "The Resources of the New England-New York Region." Part Two, Chapter V, Penobscot River Basin, Maine. 1955. (NENYIAC Studies)

b. Flood Plain Information, Penobscot and Stillwater Rivers, Old Town and Milford, Maine; Corps of Engineers, December 1975.

c. U.S. Inter-Agency Advisory Committee on Water Data, Bulletin 17B, "Guidelines for Determining Flood Flow Frequency," March 1982.

d. Flood of April 1987, In Maine, Massachusetts, and New Hampshire, U.S. Geological Survey, Open File Report 87-460.

e. Indian Island Local Protection Project, Old Town, Maine, Detailed Project Report, Corps of Engineers, January 1974.

f. Flood Insurance Study (FIS), City of Bangor, Penobscot County, ME, Federal Emergency Management (FEMA), June 1978.

g. FIS, City of Brewer, Penobscot County, ME, FEMA, December 1977.

h. FIS, Town of Howland, Penobscot County, ME, FEMA, June 1986.

i. FIS, Town of Mattawamkeag, Penobscot County, ME, FEMA, May 1988.

j. FIS, Town of Medway, Penobscot County, ME, FEMA, September 1987.

k. FIS, Town of Guilford, Piscataquis, County, ME, FEMA, January 1979.

l. FIS, City of Old Town, Penobscot County, ME, FEMA, October 1977.

m. FIS, Town of Abbot, Piscataquis County, ME, FEMA, September 1978.

n. FIS, Town of Bradley, Penobscot County, ME, FEMA, May 1978.

o. FIS, Town of Passadumkeag, Penobscot County, ME, FEMA, May 1988.

p. FIS, Town of Dover-Foxcroft, Piscataquis County, ME, FEMA, July 1979.

q. FIS, Town of Orono, Penobscot County, ME, FEMA, July 1978.

r. FIS, Town of Bradley, Penobscot County, ME, FEMA, Feburary 1977.

s. FIS, Town of Eddington, Penobscot County, ME, FEMA, January 1978.

t. FIS, Town of Milo, Piscataquis County, ME, FEMA, June 1979.

u. FIS, Town of Hampden, Penobscot County, ME, FEMA, September 1983.

3. BASIN DESCRIPTION

a. General. The Penobscot River basin, located entirely within the State of Maine, is principally in the east central portion of the State and includes an area approximately 160 miles long in a north-south direction and 115 miles wide in an east-west direction. The basin, bounded by watersheds of the St. John River on the north, the St. Croix River to the east, and the Kennebec River to the west, drains into the Atlantic Ocean at Penobscot Bay. The basin's drainage area of 8,570 square miles represents more than one-fourth of the area of the State of Maine. There are over 600 lakes and ponds within the heavily forested watershed covering 1,590 square miles or 18.5 percent of the basin's area. A map of the watershed is shown on plate 1.

b. Main River. The main Penobscot River is formed at the junction of its East and West Branches at Medway and follows a general southerly course to tidewater at Bangor, a distance of 74 miles. It then continues 31 miles further to its mouth at Turner (Steele) Point at the head of Penobscot Bay. In its 74-mile course between Medway and tidewater at Bangor, the river falls a total of about 240 feet at a fairly uniform slope averaging 3.2 feet per mile. Approximately 124 feet of this total fall (about 50 percent) are presently utilized by six hydropower developments on the river.

The Penobscot River has five major sub-watersheds; the East and West Branch Penobscot, the Mattawamkeag River, the Piscataquis River, and the Passadumkeag River. In addition, many smaller tributaries enter along its course.

c. Headwater Tributaries. The headwaters, as defined in this report, are those areas above Medway; namely, the East and West Branches of the Penobscot River, having a combined drainage area of 3,230 square miles.

(1) East Branch Penobscot River. The headwaters of the East Branch are in the western and northernmost part of the basin. In this area several small streams unite to form Allagash Stream which flows easterly 19 miles, through Allagash Lake, to Chamberlain Lake. The flow then continues in an easterly direction for 38 miles from Chamberlain Lake through a series of lakes and ponds to First Grand Lake. From the outlet of First Grand Lake, the East Branch flows in a general southerly direction for 47 miles to its junction with the West Branch at Medway. The drainage area of the East Branch is 1,120 square miles (including the 240-square mile watershed of Chamberlain Lake which has been diverted from the Allagash River in the upper Saint John River basin to the Penobscot by the Telos Canal). The total fall between Allagash Lake and the Penobscot River at Medway, a distance of 92 miles, is 805 feet. The East Branch proper, below Grand Lake, falls at an average slope of 8.8 feet per mile or a total of 414 feet in 47 miles. The greatest fall in this reach occurs seven miles below the outlet of Grand Lake where there is a drop of 130 feet in 2.5 miles, or more than 50 feet per mile.

The principal tributary of the East Branch Penobscot River is Seboois Stream which has its source at Grand Lake

Seboois located near the mid-point of the northern limit of the basin. From the outlet of its headwater lake, this stream flows in a general southerly direction, first for a distance of five miles through Snowshoe and White Horse Lakes, then 26 miles further, a total distance of 31 miles, to its confluence at a point 27 miles above the mouth of the East Branch at Medway. It has a drainage area of 275 square miles and a total fall of 302 feet for an average slope of about 10 feet per mile.

(2) West Branch Penobscot River. This tributary has its source in Seboomook Lake which is fed by a number of streams originating near the international boundary at the northwestern limit of the basin. From the outlets of Seboomook Lake, the West Branch follows a general easterly course for 97 miles through a series of large lakes to its confluence with the East Branch at Medway. The West Branch has a drainage area of 2,110 square miles and a total fall, below Seboomook Lake, of 830 feet. The maximum slope occurs in the 17-mile reach below Ripogenus Lake where there is a fall of 445 feet. The steepest part of this fall occurs immediately below the dam at the outlet of Ripogenus Lake where the river drops 275 feet in 2.5 miles, or 110 feet per mile. The power facilities installed at Ripogenus Dam utilize 184 feet of this 275-foot fall. In the lower 15.5 miles of the West Branch, there is a fall of 255 feet, of which 230 feet have been developed by existing power or storage projects.

d. Downstream Tributaries. The principal tributaries of the main stem Penobscot River below Medway are listed below in downstream order.

(1) Mattawamkeag River. The East and West Branches of the Mattawamkeag River rise in the northern part of the basin, east of Seboois Stream, and flow in a southeasterly direction 33 and 50 miles, respectively, to the town of Haynesville where they unite to form the Mattawamkeag River. From this point, the river follows a general southwesterly course for 48 miles to its confluence with the Penobscot River at Mattawamkeag, 12 miles below Medway. It has a drainage area of 1,490 square miles. The total fall in this tributary below the outlet of Pleasant and Mud Lakes, in the headwaters of the West Branch, is approximately 630 feet in 91 miles. The maximum slope occurs immediately below Mud Lake where there is a drop of 150 feet in 2.5 miles.

(2) Piscataquis River. This river rises on the southerly slope of Little Square Mountain in Township 3, Range 5, about four miles southwest of Moosehead Lake in the

adjacent Kennebec River basin, and flows southeasterly 27 miles to Guilford where the river turns easterly flowing an additional 49 miles to its mouth at the Penobscot River at Howland, 38 miles below Medway. It has a drainage area of 1,454 square miles and a total stream length of 76 miles. The total fall in this tributary is approximately 1,400 feet of which 1,030 feet are in its upper 18 miles. In its lower 58 miles, the river drops approximately 370 feet at an average slope of 6.4 feet per mile. Two major tributaries combine with the main stem Piscataquis at Milo; the Pleasant River (DA = 334 sq.mi.) and the Sebec River (DA = 352 sq. mi.). The Sebec River flows easterly from Sebec Lake dropping about 60 feet in its 9 mile length. Pleasant River is formed at the junction of its East and West Branches just north of community of Brownville Junction. It flows southeasterly to its junction with the Piscataquis River in Medford, dropping about 110 feet in its 13 mile length.

(3) Passadumkeag River. This tributary is formed by the junction of its East and West Branches in Township 3, Range 1, about 7 miles southwest of Springfield, and flows in a general westerly direction for 43 miles to its confluence with the Penobscot River at Passadumkeag, 42.5 miles below Medway. It has a drainage area of 385 square miles and a total fall of nearly 152 feet. Lakes account for 6 percent of the area within the basin. The greatest fall occurs at Morrison Mill, 25 miles above the mouth, where there is a drop of 60 feet in 0.7 mile.

(4) Kenduskeag Stream. This stream drains an area of approximately 215 square miles. Rising in the town of Corinth, it flows in a southeasterly direction to its confluence with the Penobscot River in Bangor. The stream is approximately 28 miles long with an average slope of 11.9 feet per mile.

A summary of drainage areas, tributaries, lengths and falls is shown in table 1.

e. Dams and Reservoirs. Total usable storage in the Penobscot River basin, is approximately 1,570,000 acre-feet and is summarized in table 2. This storage is located in the watersheds of the West and East Branches of the Penobscot River and in the basin of the Piscataquis River. Most of the storage - over 80 percent of the total basin storage - is in the West Branch watershed, including 689,000 acre-feet upstream of Ripogenus Dam and 345,000 acre-feet upstream of North Twin Dam. In the watershed above North Twin Dam, there are 16 small lakes and ponds with an aggregate usable storage of 230,000 acre-feet. The storage in the watershed of the

TABLE 1

PENOBSCOT RIVER AND TRIBUTARIES

River or Tributary	Drainage Area (sq.mi.)	Main Stem Length (miles)	Main Stem Fall (feet)
West Branch Penobscot River at Mouth	2110	97	830
East Branch River Penobscot River near former Grindstone USGS gage	1086	-	-
East Branch Penobscot River at Mouth	1120	92	805
Penobscot River near Mattawamkeag USGS gage	3356	-	-
Mattawamkeag River near Mattawamkeag USGS gage	1418	-	-
Mattawamkeag River at Mouth	1490	91	630
Piscataquis River near Dover-Foxcroft USGS gage	298	-	-
Sebec River at Mouth	351	15	100
Pleasant River at Mouth	334	7	60
Piscataquis River near former Medford USGS gage	1161	-	-
Piscataquis River at Mouth	1454	76	1400
Penobscot River near West Enfield USGS gage	6671	-	-
Passadunksag River at Mouth	385	43	152
Penobscot River at Veazie Dam	7763	-	-
Penobscor River near Eddington USGS gage	7764	-	-
Penobscot River at Bangor Water Works Dam	7794	-	-
Kenduskeag Stream at Mouth	215	28	335
Penobscot River at Mouth	8570	105	240

TABLE 2

AVAILABLE STORAGE - PENOBSCOT RIVER BASIN

Reservoir	Drainage area (sq.mi.)	Draw-down- (ft.)	Useable Storage (ac.-ft.)	Capacity (inches of runoff)
East Branch Penobscot River				
Telos Lake (1)	240	8.25	105,600	8.2
Grand Lakes	484 (1)	12	41,300	1.6
Total	1,120		146,900	
West Branch Penobscot River				
Small Ponds (2)	-	-	229,600	-
Ripogenus Lake (3)	1,410	44	688,700	9.1
Millinocket Lake (4)	106	-	45,900	8.1
North Twin (5)	1,864	-	344,300	3.5
Total	2,110		1,308,500	
Picataquis River				
Wilson Pond	36	6	9,000	4.7
Sebec Lake	344	7	45,900	2.5
Schoodic Lake	43	4	27,500	12.0
Seboeis Lake	-	6	23,000	2.2
Endless Lake	78	5.5	9,200	-
Total	1,454		114,600	
Basin Total	8,570		1,570,000	

(1) Dam at outlet downstream of Chamberlain and Telos Lakes and Round Pond includes about 240 sq. mi. drained by Chamberlain Lake through Telos Canal.
(2) Sixteen ponds in watershed above North Twin Dam.
(3) Dam at outlet downstream of Chesuncook, Ripogenus, and Caribou Lakes, and Moose Pond.
(4) Diverted at times to North Twin Lake.
(5) Dam outlet downstream of Ambajejus, Pemadumcook, North Twin, South Twin, and Elbow Lakes.

East Branch totals over 150,000 acre-feet of which 105,000 acre-feet are upstream of the dams at the outlets of Telos and Chamberlain Lakes. The dam at the outlet of Grand Lake controls about 41,300 acre-feet. Storage of about 115,000 acre-feet is available in 5 lakes and ponds in the Piscataquis River watershed. In addition, there are a number of small storages on other tributaries of the Penobscot River.

All of the storage on the East Branch Penobscot River is operated by the Bangor Hydro-Electric Company for use at hydropower plants on the Penobscot River below Medway. Similarly, the usable storage in the watershed of the West Branch Penobscot River is operated by the Great Northern Paper Company for power purposes.

About 9,000 acre-feet of storage in Wilson Pond, in the Piscataquis River basin, is utilized by the Central Maine Power Company for the development of power at its plant on Wilson Stream. The balance of storage in the Piscataquis River basin, totaling approximately 105,600 acre-feet in Sebec, Schoodic, Seboeis, and Endless Lakes, is owned and operated by the Bangor Hydro-Electric Company for the purpose of regulating flows at its plants on the Sebec, Piscataquis, and Penobscot Rivers.

4. CLIMATOLOGY

The Penobscot River basin, representing more than one-fourth of the State of Maine, has significant variations in surface elevations (from Mount Katahdin at 5,267 feet NGVD to sea level at coastal Maine), local relief, and exposure and latitudinal spread. The climate, classified as generally cool semi-humid continental, is quite variable within the basin having frequent but short periods of heavy precipitation. The summers are relatively cool and the winters, especially at inland points, are usually severe. The basin lies in the path of the "prevailing westerlies" and the cyclonic disturbances that cross the country from the west or southwest towards the east or northeast. The area is also exposed to coastal storms, some of tropical origin, that travel up the Atlantic seaboard. Due to its northerly location, the basin has escaped the brunt of coastal hurricanes with their accompanying intense rainfall. The basin's average annual temperature is 42° F. The range of mean monthly temperatures is wide, with 63 to 68° F. in July and August to 12 to 20° F. in January and February. Temperature extremes range from occasional highs over 95° F. to lows down to -30° F. Table 3 lists monthly and annual temperatures at Bangor, Orono, Patten, Dover-Foxcroft,

TABLE 3

MONTHLY TEMPERATURES
(Degrees, Fahrenheit)

Month	Bangor Elevation 60 Ft. NGVD Before 1963 Elevation 190 Ft. NGVD After 1953 63 Years of Record (1923 - 1986)			Orono Elevation 120 Ft. NGVD 38 Years of Record (1948 - 1986)		
	Mean	Max	Min	Mean	Max	Min
January	18	40	-2	-	35	0
February	20	41	-2	-	42	1
March	30	51	12	-	47	14
April	42	61	25	-	57	28
May	53	74	38	-	72	36
June	63	83	46	-	80	47
July	68	96	53	-	87	50
August	66	89	44	-	82	47
September	58	79	42	-	75	39
October	48	68	29	-	64	33
November	37	52	17	-	51	23
December	23	41	0	-	40	5
ANNUAL	44	96	-2	-	87	0

Month	Millinocket Elevation 360 Ft. NGVD 39 Years of Record (1947 - 1986)			Patten Elev. var. from 800 to 600 ft. NGVD 19 Years of Record (1967 - 1986)		
	Mean	Max	Min	Mean	Max	Min
January	14	31	-6	-	28	-2
February	16	36	-5	-	30	-1
March	28	34	10	-	44	11
Arpil	40	56	26	-	54	25
May	52	70	35	-	69	35
June	62	79	47	-	77	45
June	68	87	53	-	82	51
August	65	81	50	-	78	49
September	57	74	39	-	71	40
October	46	63	31	-	59	30
November	35	48	21	-	44	18
December	20	37	1	-	32	-1
ANNUAL	42	87	-6	-	91	-2

TABLE 3 (Continued)

MONTHLY TEMPERATURES
(Degrees, Fahrenheit)

Month	Dover-Foxcroft Elevation 460 Ft. NGVD 13 Years of Record (1973 - 1986)			Ripogenus Dam Elevation 970 Ft. NGVD 39 Years of Record (1947 - 1986)		
	Mean	Max	Min	Mean	Max	Min
January	-	28	-7	12	28	-10
February	-	36	2	13	34	-9
March	-	43	11	24	41	1
Arpil	-	55	24	36	52	22
May	-	67	38	49	70	31
June	-	76	45	60	77	45
June	-	81	50	65	85	50
August	-	81	46	63	81	49
September	-	73	38	55	75	38
October	-	59	27	44	61	29
November	-	47	18	32	46	19
December	-	38	0	17	34	-3
ANNUAL	-	81	-7	39	85	-10

Millinocket and Ripogenus Dam in Maine. Average annual precipitation is 41 inches distributed uniformly throughout the year. Average monthly and annual precipitation is listed in table 4. Most of the winter precipitation is in the form of snow. Annual snowfall varies from about 70 inches at Old Town to 120 inches at Ripogenus Dam. Water content of the snow cover in early spring is about 6 to 8 inches; 10 inches is common in the upper areas of the watershed. Table 5 lists mean monthly and annual snowfall at 6 locations within the basin.

5. STREAMFLOW

a. Runoff. Average annual streamflow is approximately 1.8 cfs per square mile of drainage area. This is equivalent to 24.3 inches of runoff, or about 60% of the average annual precipitation. Over 40 percent of the runoff occurs during the snowmelt season of March, April and May, with the rest uniformly distributed throughout the year.

b. Steamflow Records. The U.S. Geological Survey (USGS) has operated a system of 20 streamflow gaging stations at various sites and for various periods of time in the basin since 1899. Six stations are presently in operation. Records are also maintained by local dam operators for power and paper companies, including the Bangor Hydro-Electric Company on the Penobscot and Stillwater Rivers and the Great Northern Paper Company for the dams on the West Branch Penobscot River. Table 6 lists the gages used in the analysis of the Penobscot River basin floods. It is unfortunate that some of the gaging stations have been discontinued, and many of the tributaries have never been gaged. Supplemental flow data for the recent 1987 flood was furnished by the Great Northern Paper Company for the West Branch.

6. FLOOD HISTORY

a. General. The history of floods in the Penobscot River basin goes back nearly 150 years with records indicating the occurrences of floods in 1846, 1853, and 1866, and on the Piscataquis River in 1857, 1869, and 1895. However, information on the relative magnitude of flood events is generally not available prior to 1901 when a gage was established at West Enfield by the USGS. Major floods in the Penobscot basin are caused principally by a combination of heavy rainfall and melting snow in the spring of the year. Most flood events occur in months of March, April and May and vary in magnitude depending on the water content of the melting snow cover, the occurrence of coincidental heavy

TABLE 4

MONTHLY PRECIPITATION RECORDS
MEAN VALUE IN INCHES

Month	Bangor Elevation 60 Ft. NGVD Before 1963 Elevation 190 Ft. NGVD After 1953 63 Years of Record (1923 - 1986)	Orono Elevation 120 Ft. NGVD 38 Years of Record (1948 - 1986)
January	3.23	3.08
February	2.88	2.80
March	3.39	2.73
April	3.29	2.87
May	3.46	3.00
June	3.13	2.99
July	3.33	3.29
August	3.09	3.30
September	3.43	3.40
October	3.57	3.21
November	4.15	4.11
December	3.59	3.63
ANNUAL	40.44	39.10

Month	Millinocket Elevation 360 Ft. NGVD 39 Years of Record (1947 - 1986)	Patten Elev. var. from 800 to 600 ft. NGVD 19 Years of Record (1967 - 1986)
January	3.02	3.83
February	2.89	2.65
March	2.90	3.52
April	3.27	3.23
May	3.16	4.06
June	3.76	4.50
July	3.92	4.44
August	3.90	3.84
September	3.41	4.02
October	3.48	3.37
November	4.48	4.05
December	3.79	3.52
ANNUAL	41.95	47.71

TABLE 4 (Continued)

MONTHLY PRECIPITATION RECORDS
MEAN VALUE IN INCHES

Month	Dover-Foxcroft Elevation 460 Ft. NGVD 13 Years of Record (1973 - 1986)	Ripogenus Dam Elevation 970 Ft. NGVD 39 Years of Record (1947 - 1986)
January	4.07	2.56
February	2.78	2.36
March	3.37	2.55
April	4.16	2.88
May	3.74	3.10
June	4.13	3.72
July	3.99	4.18
August	3.95	3.92
September	3.94	3.28
October	3.86	3.46
November	3.81	3.74
December	4.18	3.17
ANNUAL	45.77	38.67

TABLE 5

MEAN MONTHLY SNOWFALL
(Depth in Inches)

Bangor Elevation 60 Ft. NGVD before 1953 Elevation 190 Ft. NGVD after 1953 61 Years of Record (1925 - 1986)		Dover-Foxcroft Elevation 460 Ft. NGVD 13 Years of Record (1973 - 1986)
Month	Snowfall	Snowfall
January	19.28	28.71
February	17.61	18.31
March	11.61	16.23
April	3.68	10.74
May	0.21	0.07
June	0.00	0.00
July	0.00	0.00
August	0.00	0.00
September	0.00	0.00
October	0.41	0.85
November	4.88	7.22
December	12.44	22.28
ANNUAL	66.44	104.57

Millinocket Elevation 360 Ft. NGVD 39 Years of Record (1947 - 1986)		Patten Elev. varies from 800 to 600 ft. NGVD 19 Years of Record (1967 - 1986)
Month	Snowfall	Snowfall
January	22.23	25.0
February	21.16	21.3
March	16.24	18.4
April	5.88	9.84
May	0.20	0.43
June	0.00	0.00
July	0.00	0.00
August	0.00	0.00
September	0.00	0.00
October	0.77	0.37
November	7.48	10.18
December	21.66	25.30
ANNUAL	101.10	112.44

TABLE 5 (Continued)

MEAN MONTHLY SNOWFALL
(Depth in Inches)

Month	Orono Elevation 120 Ft. NGVD 38 Years of Record (1948 - 1986) Snowfall	Ripogenus Dam Elevation 970 Ft. NGVD 39 Years of Record (1947 - 1986) Snowfall
January	19.21	25.65
February	18.72	23.43
March	11.35	20.43
April	3.61	7.97
May	0.14	0.38
June	0.00	0.00
July	0.00	0.00
August	0.00	0.00
September	0.00	0.00
October	0.59	1.82
November	4.68	9.31
December	17.75	26.66
ANNUAL	81.01	121.30

TABLE 6

STREAMFLOW RECORDS - PENOBSCOT RIVER BASIN

Location of Gaging Station	Drainage Area (sq. mi.)	Period of Record	Discharge (cfs) Mean	Max	Second Highest	Third Highest
East Branch Penobscot at Grindstone	1090	1903 - 1982	1,949	37,000 (4/30/23)	30,600 (4/29/73)	26,900 (3/20/36)
Penobscot River at Mattawamkeag	3356	1941 -	5,835	66,000 (4/29/73)	55,400 (4/2/87)	53,000 (4/29/79)
Mattawamkeag River at Mattawamkeag	1418	1935 -	1,307	29,200 (3/23/36)	27,600 (4/6/76)	25,400 (4/26/58)
Piscataquis River at Dover-Foxcroft	298	1903 -	605	37,600 (4/1/87)	22,800 (11/4/66)	21,500 (4/29/23)
Sebec River at Sebec	326	1925 -	629	13,400 (4/2/87)	11,400 (3/20/36)	9,010 (11/4/66)
Pleasant River at Milo	324	1921 - 1979	712	28,600 (11/4/66)	24,400 (4/30/23)	23,400 (3/20/36)
Piscataquis River at Medford	1161	1925 - 1982 +1987	2,356	85,000 (4/2/87)	60,100 (11/4/66)	50,200 (3/20/36)
Penobscot River at West Enfield	6671	1902 -	11,950	153,000 (5/1/23)	145,000 (4/3/87)	128,000 (4/30/73)
Passadumkeag River at Lowell	299	1916 - 1979	506	5,680 (5/2/23)	4,020 (3/20/36)	3,660 (4/5/76)
Penobscot River at Eddington	7764	1979 - 1987	15,140	156,600 (4/3/87)	136,000 (6/4/84)	133,600 (4/20/83)
Kenduskeag Stream at Kenduskeag	178	1942 - 1979 +1987	326	7,400 (4/2/87)	6,440 (9/12/54)	6,380 (4/4/59)

spring rainfall, temperature and the extent of frost. The four greatest known basin-wide floods; April/May 1923, March 1936, April/May 1973 and March/April 1987, were a result of a combination of these factors. Discharges and stages of spring floods can also be increased due to the formation of ice jams. This occurred throughout the basin during the March 1936 event. Heavy rainfall at other times can also produce flooding as evidenced by the floods of September 1909, June 1917, November 1943, November 1950, and November 1966.

The lower portion of the Penobscot River below Bangor is tidal. Available information indicates that there has been only one historic flood which has not been attributable to high streamflow (ref. f). The flooding of 2 February 1976 was the result of a tidal storm surge caused by extremely high southerly winds and very low barometric pressure (28.10 inches) creating flood levels along the entire length of the tidal estuary. Winds of 100 knots were recorded at Southwest Harbor, while at Bangor International Airport winds of 40 knots, gusting to 60 knots, were logged.

b. May 1923. The flood of 1 May 1923 was the greatest known flood on the main stem of the Penobscot River. It was caused by three days of rainfall on a snow-covered basin. The storm had a maximum recorded precipitation of 5.3 inches at Millinocket. Considerable damage was done to streets and houses in Costigan, Bradley and Old Town. The latter was without power, water or electricity for several days. The major property losses during this event consisted largely of damages to dams and mills. Flow at the West Enfield gage was recorded at 153,000 cfs. Due to lack of data, this flood could not be analyzed hydrologically.

c. March/April 1987. The March/April 1987 flood, the second largest basin-wide storm, was caused by a pair of intense rainstorms, augmented by snowmelt in the higher elevations of the basin. The first storm occurring from 31 March to 1 April, was a fast moving storm system with heavy rainfall, strong southerly winds, and temperatures in the 50's and 60's. Two to 4 inches of rain fell over the Penobscot on snowpacks with 3 to 5 inches of water equivalent. The second storm, 4 to 8 April, was an intense, slow-moving storm, however, its impact generally produced flooding primarily in southern New Hampshire and Massachusetts. As a result of the first storm, major flooding was experienced in the Piscataquis River subbasin with lesser damages occurring on the lower part of the Penobscot from West Enfield to Bangor. This event produced the flood of record on the Piscataquis; the USGS estimated a peak flow at Medford of 85,000 cfs. The recorded peak flow on the Penobscot at West Enfield and Eddington was 145,000 and 152,000 cfs, respectively.

d. April/May 1973. One of the more recent flooding events to affect the Penobscot River watershed occurred during April/May 1973 and was produced by 3 inches of rainfall over the basin during the snowmelt season. As in the past, streets in Bradley were heavily damaged, homes in Costigan and Old Town were flooded, over $60,000 of industrial damage was reported in Old Town, and Route 2 throughout Costigan area was inundated. Peak flow at the West Enfield gage was measured at 128,000 cfs.

e. March 1936. Although flows from March 1936 flood were less than the 1973, 1987 and 1923 storms, ice conditions along Penobscot and Stillwater Rivers created problems of significant magnitude in the lower Penobscot River. Severe winter conditions resulted in frozen ground, deep snows, and thick ice deposits in the upstream reaches of the Penobscot. These conditions, coupled with the heaviest amounts of rainfall known in certain areas, resulted in record flooding and damage in many river basins in Maine. Throughout the lower basin area, huge ice packs threatened the highway bridges. Although the peak discharge at West Enfield was 125,000 cfs, due to the extent of ice, experienced stages along the lower Penobscot were comparable to the recent April 1987 event. Records at Milford Dam on the Penobscot and at Gilman Falls on the Stillwater River indicate peak flows of 87,500 cfs and 38,000 cfs, respectively.

7. DISCHARGE FREQUENCIES

a. General. Peak discharge frequencies were developed at selected USGS gaging stations within the watershed. In general, statistical analysis of the recorded peak annual flows (including March/April 1987, where available) were performed using a Log Pearson Type III distribution in accordance with guidelines as presented in WRC Bulletin 17B (ref. c).

It is noted that analyses conducted during New England-New York Inter-Agency Committee (NENYIAC) studies, which at the time had about 50 years of available flow data, resulted in computed skew coefficients for the Penobscot River watershed ranging from 0.4 to 0.5. In the current analysis, all available flow data were used to compute pertinent statistics, including the skew coefficient, at all gaging stations analyzed. Computed skew coefficients for the main stem Penobscot ranged from about 0 to 0.1, however, computed skew coefficients for tributaries ranged from -0.1 to 0.5. It is also noted that the regional skew coefficients obtained from Bulletin 17B, (ref. c) is about 0.3. Therefore, when assessing potential flood control improvements, the regional skew coefficient was adopted as a minimum and if analyses of individual gaging station data indicated a higher computed skew, the higher skew value was adopted for use.

Comparisons of discharge frequency relationships from this investigation were made with discharge-frequency relationships developed during various flood insurance studies (FIS) within the basin. Most of these FIS were completed in the late 1970's and early 1980's. In general, this study's discharge-frequency relationships were greater in magnitude since several major runoff events, including the 1987 event, occurred during the mid to late 1980's. As a result, stage-frequency relationships described in the next section reflect the results of this trend, showing slightly higher elevations for a given flood-frequency than those shown in the various FIS.

b. Main Stem - Penobscot River. Peak discharge frequencies were developed for the Penobscot River by analysis of the long term gaged records (1902 to 1985, plus 1987 - 85 years) at the West Enfield gaging station (DA = 6,671 sq. mi.). Another gaging station at Eddington, Maine has a larger drainage area (7,764 sq. mi.); however, it was not analyzed statistically due to the very short period of record (1979 to 1985, plus 1987). Therefore, the 86 years of record at West Enfield were analyzed resulting in a mean log of 4.7957, standard deviation of 0.1702, and a computed skew of 0.037. The regional skew of 0.3 was adopted. The resulting curve was transferred downstream to Old Town, Orono and Bangor population centers by the drainage area ratio to the 0.7 exponential power. As a check for reasonableness, the recorded peak flows for Water Years 1979, 1981 through 1984 and 1987 at Eddington (7,764 square miles) and West Enfield (6,671 square miles) were reviewed. The percentage increase in discharge from West Enfield to Eddington varied for each flood event reviewed; however, the increase averaged about 11 percent. Using the drainage area ratio to 0.7 power increased computed discharge frequencies about 11 percent and, therefore, is considered reasonable. Discharge frequencies were also developed upstream at Mattawamkeag, Maine (DA = 3,356 sq. mi.). The 46 years of record (1941 - 1985, plus 1987), were analyzed using a Log Pearson Type III distribution resulting in mean log of 4.4311, a standard deviation of 4.1806, and a computed skew of 0.01. Again, the regional skew of 0.3 was adopted for use. Five adopted Penobscot River basin discharge frequency curves are shown on plate 2.

c. Tributaries. Peak discharge frequencies were also developed for the following tributaries within the Penobscot River basin: the Stillwater River, the Piscataquis River, the Sebec River, and the Mattawamkeag River. The computed curves, along with the resulting statistics for each curve, are shown on plate 2.

(1) Stillwater River. In the area between Old Town and Orono, the river divides for a short length into the main stem Penobscot and the Stillwater Rivers. Historical data collected by the Bangor Electric Co., which operates run-of-river power dams on both the Penobscot and Stillwater Rivers, was used to estimate floodflow distribution between the two rivers. Total flow upstream of the split was determined based on discharge records at the West Enfield gage after they are transferred downstream by drainage area ratio. During past studies it was estimated, based on measured flow at the Milford Dam on the Penobscot River and at the Gilman Falls Dam on the Stillwater River, that the flow divides generally at a ratio of about 30 percent to the Stillwater River and 70 percent to the main stem Penobscot River. Based on this distribution of flow, the adopted discharge frequency curve for the Stillwater River at Old Town and the main stem Penobscot River below the split at Milford were developed.

(2) Piscataquis River. Peak discharge frequencies were developed for the Piscataquis River at Medford, Maine (DA = 1,161 sq. mi.). The USGS had recorded river flows at this location from 1925 to 1982 (58 years), unfortunately the gaging station was discontinued in 1982. The USGS, however, did make estimates of the record 1987 peak flow on the Piscataquis River. Therefore, the 59 years of record were analyzed in a Log Pearson Type III distribution resulting in a mean log of 4.3377, standard deviation 0.2078, and a computed skew of 0.3739. A skew of 0.3 was adopted. In addition, peak discharge frequencies were developed for the Piscataquis River at Dover-Foxcroft, Maine (DA = 298 sq. mi.), which has 84 years of record (1903 to 1985, plus 1987), resulting in a mean log 3.9191, standard deviation 0.2178, and computed skew of 0.1592. A skew of 0.3 was also adopted at this location. The curves were transferred to areas of concern by drainage area ratio to the 0.7 exponential power.

(3) Sebec River. Peak discharge frequencies were developed for the Sebec River by analysis of the gaged records (DA = 326 sq. mi.; period of record, 1925 to 1985, plus 1987). The 60 plus years of record were analyzed in a Log Pearson Type III distribution resulting in a mean log of 3.5852, standard deviation of 0.1780, and a computed skew of 0.5142. A skew of 0.5 was adopted for use.

(4) Mattawamkeag River. Peak discharge frequencies were developed for the Mattawamkeag River at Mattawamkeag, Maine (DA = 1,418 sq. mi.; period of record 1935 to 1985, plus 1987). The 52 years of record were analyzed in a Log Pearson Type III distribution resulting in a mean log of 4.2190, standard deviation 0.1268 and computed skew of -0.1710. The regional skew of 0.3 was adopted for use.

8. STAGE FREQUENCIES

As part of the NENYIAC studies, the Corps of Engineers conducted extensive damage surveys throughout the watershed. As a result of these investigations, areas having the highest damage potential were found along the Penobscot River, generally in the Bangor-Old Town area and along the Piscataquis River from Dover-Foxcroft to Howland. Information obtained from the recent Corps of Engineers damage surveys indicated that the flood of April/May 1987 generally confirmed the NENYIAC findings relating to damage areas and therefore development of stage frequency curves were concentrated in these same areas. A total of 14 different communities were investigated; Abbot, Bangor, Bradley, Brewer, Costigan, Dover-Foxcroft, Eddington, Guilford, Howland, Milford, Milo, Old Town, Orono, and Passadumkeag. Peak stage frequencies in most of those areas have been determined based on the adopted discharge frequency curves and stage rating curves developed from profiles presented in flood insurance studies for the communities along the various rivers. The developed stage discharge rating curves were in general agreement with surveyed historic high water mark information and the estimated corresponding discharge. Stage frequency data is presented in table 7. Also shown are the 1923, 1936 and 1987 high water mark data where available. Pertinent stage frequency curves are graphically shown on plates 3A and 3B.

When attempting to develop stage frequency curves at Bangor and Brewer along the Penobscot River and at Howland along the Piscataquis River, several discrepancies were noted.

Computed flood profiles at Howland appeared to be considerably higher than observed elevations. The 1987 flood on the Piscataquis was about 40 percent greater in discharge than the previous record November 1966 flood and the 1987 peak discharge was about 15-20 percent higher than the 100-year discharge adopted for use in the Howland Flood Insurance Study. However, high water mark data was 4-5 feet lower than the 100-year flood profile for the town near the Howland Dam. Analysis used in the flood insurance study apparently assumed

TABLE 7
ELEVATION - FREQUENCY DATA

River Mile	Location	Elevations (ft, NGVD) 10-yr	50-yr	100-yr	500-yr	1923	1936	1987
	Penobscot River							
66.7	West Enfield USGS Gage	145.3	149.7	151.7	156.6	151+/-	147.2	149.5
61.7	Confluence with Passadumkeag River	135.7	140.2	142.2	147.1	-	-	-
47.8	Old Town/Alton Town Line	118.6	122.9	124.5	128.1	-	-	-
46.5	D/S Confluence with Sunkhaze Stream in Milford	116.9	121.1	122.8	126.3	-	120.6	-
44.9	0.3 mile D/S Stillwater River Divergeance	113.5	116.9	118.4	122.1	-	-	-
43.6	0.3 mile U/S Milford Dam	106.2	109.0	110.2	112.7	-	-	-
43.3	U/S Milford Dam	106.1	108.4	109.4	112.1	110.2	107.1	107.2
42.7	0.3 mile D/S Route 2 Bridge in Old Town	91.4	93.1	96.8	100.3	-	95.6	95.1
41.3	U/S Great Works Dam in Old Town	84.5	88.8	90.0	92.4	-	88.2	-
41.0	0.3 mile D/S Great Works Dam in Bradley	76.3	81.4	83.2	86.7	81.7	81.1	-
38.3	0.3 mile U/S Confluence with Stillwater River	56.4	60.1	61.4	64.0	-	-	-
37.0	0.9 mile D/S Confluence with Stillwater River	46.4	50.6	52.3	56.0	-	50.5	-
34.4	0.2 mile D/S from Veazie Dam	29.6	34.3	35.9	39.2	-	36.2	31.1
31.8	1.1 miles U/S Breached Bangor Water Works Dam	(assuming complete breach)						
29.0	Confluence with Kenduskeag Stream	13.9	15.8	17.0	19.5	-	16.0	14.3

NOTE: Peak stage frequencies have been determined based on adopted discharge frequency curves and the stage rating curves developed from profiles presented in flood insurance studies.

TABLE 7 (cont.)
ELEVATION - FREQUENCY DATA

River Mile	Location	Elevation (ft. NGVD) 10-yr	50-yr	100-yr	500-yr	1923	1936	1987
	Stillwater River							
5.7	D/S Rt. 43 Bridge in Old Town	103.1	106.1	107.3	110.2	-	-	104.2
2.7	U/S Stillwater Ave. Bridge in Old Town	98.4	100.8	101.9	104.3	-	101.4	100.7
2.6	U/S Stillwater Dam in Old Town	97.2	98.8	99.6	101.1	-	98.3	96.5
	Piscataquis River							
54.1	Confluence with Kingsbury Str.	397.7	401.5	403.1	406.9	-	-	-
48.8	U/S Guilford Dam in Guilford	394.2	396.7	398.1	400.7	-	395.3	398.7
48.6	0.2 mile D/S Guilford Dam in Guilford	384.3	389.7	392.2	397.6	-	387.2	-
40.2	U/S Foxcroft Dam in Dover-Foxcroft	351.0	353.8	355.2	358.7	-	350.2	356.4
40.2	D/S Foxcroft Dam in Dover-Foxcroft	339.7	344.2	345.8	350.4	-	338.8	-
39.9	U/S Brown Dam in Dover-Foxcroft	336.7	340.0	342.2	347.5	-	335.8	-
39.7	D/S Brown Dam in Dover-Foxcroft	314.5	318.7	320.6	325.0	-	313.5	-
0.1	U/S Howland Dam	151.7	153.3	154.1	156.8	-	152.3	154.5
	Sebec River							
2.0	D/S Milo Dam	280.5	285.5	287.5	291.6	-	-	288.2

that all flow remained in the river channel. Results of field investigations indicate that during the 1987 flood, water escapes the river channel upstream of the Howland Dam and Route 116 bridge and flows through the center of Howland bypassing the dam. This situation results in flood elevations considerably lower, for rarer flood events, than indicated in the computed flood profiles in the Howland Flood Insurance Study. Therefore, when developing a discharge rating curve at Howland, the flood insurance study profiles and discharges were used for the more frequent flood events, however, the surveyed 1987 flood elevation and estimated discharge was used as a guide to extend the rating curve for rarer flood events. This curve was then used along with adopted discharge frequencies to develop the existing condition stage frequency curve.

At Brewer, conditions have changed since the flood insurance studies were completed in the late 1970's as a result of the breaching of the Bangor Water Works Dam. This dam formerly established the limit of tidal influence along the Penobscot. Approximately 10 years ago, the dam began to breach and the opening is continuing to increase at this time. Water levels upstream of the dam are estimated to have dropped between 2 to 8 feet from those shown in the flood insurance studies. The actual stage is dependent upon the discharge in the river and the condition of the dam at the time of the measured flow. Two curves have been presented for Brewer on plate 3; one showing pre-breach conditions and estimated complete post-breach conditions upstream from the dam. The applicable curve at the present time would be somewhere in between. Apparently, there are no plans of reconstructing the dam. If its current condition is not stabilized, future high river flows will continue to increase the size of the breach resulting in near complete breaching sometime in the future.

In reviewing surveyed flood elevations for the 1936 and 1987 flood events along the Penobscot River in Bangor, additional discrepancies were noted. Surveyed flood elevations near the confluence of the Kenduskeag Stream and the Penobscot River were not consistent between the two events based on the magnitude of the respective peak discharges. The 1936 flood had a peak discharge about 15 percent less than the 1987 event, however, experienced stages were almost 2 feet higher for the 1936 flood. Factors considered in assessing this area included:

a. The Penobscot River is a long, flat tidal estuary having a mean tide range of about 13.5 feet at Bangor. A difference in the timing and magnitude of high tide levels could have an impact on flood stages. For example, the same area received flood damages from a coastal storm tidal surge during the 2 February 1976 event. Also, even though the 1987 flood produced a greater peak flow, the hydraulic characteristics of the long, flat river reach could result in peak flood elevations being the result of flood volume rather than peak discharge.

b. High-water data is limited to two events. Of the two, the 1936 event was the only one affected by ice blockages. The degree to which ice may have raised the stage is unknown, however.

c. Due to the complex hydraulic nature of this reach of river, stage frequencies were developed by assigning the two surveyed flood elevations (1936, 1987) Weibull plotting positions and a sketched curve using hydrologic engineering judgment. It is noted that while these curves do not differ appreciably from the elevations presented in the various flood insurance studies, the development for the two is not consistent.

As determined from the various hydraulic analyses and surveyed high water mark information, river stages during major flood events rise to between 10 and 20 feet above normal along the Penobscot River between Howland and Bangor and between 10 and 25 feet above normal along the Piscataquis River between Dover-Foxcroft and Howland.

9. ANALYSIS OF FLOODS

a. General. For this study, the floods of record, with the exception of the 1923 flood, were analyzed to determine the hydrologic development of floods and tributary contributions to flood peaks on the main stem. This analysis is essential to determine the flood potential of the basin and to recognize the tributaries or subwatershed areas that offer the most potential for reduction of main stem flood levels. The basin was divided into reaches with the key index stations located at the USGS gaging stations at Dover-Foxcroft and Medford on the Piscataquis River and at Mattawamkeag, West Enfield and Eddington on the Penobscot River. In addition, other key locations were identified at mouths of larger tributaries and at other points along the Piscataquis and the main stem Penobscot. Streamflow data from the USGS, the Bangor Hydro-Electric and the Great Northern Paper Company was used where available for this analysis. In some cases, where only the peak flow was known, ungaged area hydrographs were developed using characteristically similar gaged watersheds.

Flood hydrographs were routed downstream along the main stem of the Penobscot from the junction of the East and West Branches to Bangor and along the Piscataquis River from Dover-Foxcroft to Howland using the progressive lag method of routing. The basin was divided into tributary and local watersheds based on available data. Allowances were made for travel time, characteristics of the river reach, amount of intervening flow, and relative timing of peak flows.

Routing coefficients were calculated initially by trial and error through reproduction of the March 1936 flood. Thereafter, the coefficients were modified slightly when further floods were analyzed during the development of a Typical Tributary Contribution Flood which is a typical distribution or average flood over the basin and was developed by the New England Division, Corps of Engineers (ref. a). These coefficients, as developed in the NENYIAC study and used in this investigation, are shown in table 8. Flood hydrograph analysis for the 1936, 1973 and 1987 events based on these coefficients are shown on plates 4, 5, and 6, respectively.

The flood of April 1923 was not analyzed because there was insufficient gaged data available to analyze the individual components and determine flood development.

b. March 1936. Eight USGS gages provided data for the March 1936 event; East Branch Penobscot River at Grindstone, Mattawamkeag River at Mattawamkeag, Piscataquis River at Dover-Foxcroft and Medford; Sebec River at Sebec, Pleasant River at Milo, Passadumkeag River at Lowell, and the Penobscot River at West Enfield. In addition, data supplied by the Bangor Hydroelectric Company for the Stillwater and lower Penobscot and by the Great Northern Paper Company for the West Branch Penobscot enabled a reasonable depiction of the flood movement throughout the basin. Flood routing was completed using the progressive lag coefficients discussed previously. Resulting hydrographs and a representation of the tributary contributions are presented in plate 4.

c. April/May 1973. Records at nine USGS gaging stations were available for use in the analysis of the April/May 1973 event; including gages at the same locations as those in March 1936 with the exception that the Dover-Foxcroft gage was inoperable and two additional gages had been added at the Kenduskeag Stream at Kenduskeag and the Penobscot River near Mattawamkeag. No data was available from the Great Northern Paper Company for the West Branch Penobscot River and data collected along the lower Penobscot River and the Stillwater River was questioned since the peak flow rates appear to

TABLE 8

ROUTING COEFFICIENTS
PROGRESSIVE LAG METHOD

PENOBSCOT RIVER

Reach Number	Location	Routing Coefficient
1	Confluence of East and West Branch to mouth of Mattawamkeag River	3/1 (Average of 3 values, with median lagged one 6-hour period.)
2	Mouth of Mattawamkeag River to mouth of Piscataquis River	5/2
3	Mouth of Piscataquis River to Sunkhaze Stream	7/1
4	Sunkhaze Stream to Eddington (Veazie Dam)	3/1

PISCATAQUIS RIVER

Reach Number	Location	Routing Coefficient
1	Dover-Foxcroft to Sebec River	9/3
2	Sebec River to Pleasant River	3/1
3	Pleasant River to mouth of Piscataquis River	5/1

NOTE: Flow estimates are at 6-hour increments.

reduce significantly as one proceeds downstream. Therefore, the analysis was terminated at West Enfield.

Accurate depiction of the individual flood peak contributions of the West Branch Penobscot River and the Piscataquis River above Dover-Foxcroft was not possible because of the lack of gaged data in these areas. Resulting hydrographs and tributary contributions are presented on plate 5.

d. March/April 1987. Runoff data was available for the March/April 1987 flood from six USGS gaging stations including the Penobscot River near Mattawamkeag, West Enfield and Eddington, the Piscataquis River at Dover-Foxcroft, the Sebec River at Sebec, and the Mattawamkeag River at Mattawamkeag. Estimates of peak flow were made by the USGS on the Piscataquis River at Medford and the Kenduskeag Stream at Kenduskeag although exact timing of the peaks was not available. In addition, Great Northern Paper Company supplied flow data for the West Branch Penobscot River near its confluence with the East Branch. No data was available for the East Branch Penobscot, therefore, the peak contribution from the East Branch alone could not be determined. Resulting hydrographs and the tributary contributions are presented in plate 6.

e. Results. Flood hydrographs and tributary contributions for the three floods analyzed are shown on plates 4, 5, and 6 and a summary of component contributions to flood peaks is shown in table 9.

(1) Headwaters - Penobscot River. The East and West Branch watersheds, containing 3,230 square miles or 37% of the Penobscot River watershed form the headwaters of Penobscot River as they join in Medway. The West Branch with a drainage area of 2,110 square miles or about 31 percent of the basin at the West Enfield gage or 25 percent of the total drainage area, historically has contributed very little to flood events due to the large storage capacities of its reservoirs. The Great Northern Paper Company operates the large hydropower storage reservoirs within the West Branch. Operation of these reservoirs generally results in a gradual drawdown throughout the summer and fall allowing for a relatively large amount of available storage prior to spring runoff. Historically, this operation has greatly reduced the West Branch's contribution to main stem flood peaks. This is demonstrated by the 1936 and the 1987 floods where, as indicated on plates 4 and 6, the West Branch's contribution to peak flows at West Enfield averaged about 4 percent. Flood events can occur, however, at a time of year when

TABLE 9

PENOBSCOT RIVER BASIN

COMPONENT CONTRIBUTIONS TO FLOOD PEAKS

PENOBSCOT RIVER

LOCATION	CONTRIBUTING COMPONENT	DRAINAGE AREA (SQ. MI.)	DRAINAGE AREA (PERCENT)	PERCENT CONTRIBUTIONS TO PEAK FLOW (MARCH 1936)	PERCENT CONTRIBUTIONS TO PEAK FLOW (APRIL 1973)	PERCENT CONTRIBUTIONS TO PEAK FLOW (APRIL 1987)
Mouth of Mattawamkeag River	West Branch	2120	43.7	8	53	4
	East Branch	1110	22.9	41	27	73
	Local to Mattawamkeag R.	126	2.6	10	a	d
	Mattawamkeag R.	1490	30.8	41	20	23
		----	----	--	--	--
	Total	4846	100.0	100	100	100
West Enfield	West Branch	2120	31.8	4	44	2
	East Branch	1110	16.7	19	21	30
	Local to Mattawamkeag R.	126	1.9	5	a	d
	Mattawamkeag R.	1490	22.3	20	17	13
	Local to West Enfield	371	5.5	7	b	2
	Piscataquis R.	1454	21.8	45	18	53
		----	----	---	--	--
	Total	6671	100.0	100	100	100
Eddington (Veazie Dam)	West Branch	2120	27.3	4	INSUFFICIENT	2
	East Branch	1110	14.3	17	DATA	28
	Local to Mattawamkeag R.	126	1.6	4	"	d
	Mattawamkeag R.	1490	19.2	19	"	11
	Local to West Enfield	371	4.8	6	"	2
	Piscataquis R.	1454	18.7	40	"	44
	Passadumkeag R.	385	5.0	4	"	e
	Local to Eddington	708	9.1	6	"	13
		----	----	--		--
	Total	7764	100.0	100		100

TABLE 9 (CONT.)

PENOBSCOT RIVER BASIN

COMPONENT CONTRIBUTIONS
TO FLOOD PEAKS

PISCATAQUIS RIVER

LOCATION	CONTRIBUTING COMPONENTS	DRAINAGE AREA (SQ. MI.)	DRAINAGE AREA (PERCENT)	PERCENT CONTRIBUTIONS TO PEAK FLOW (MARCH 1936)	PERCENT CONTRIBUTIONS TO PEAK FLOW (APRIL 1973)	PERCENT CONTRIBUTIONS TO PEAK FLOW (APRIL 1987)
Mouth of Piscataquis River	Above Dover-Foxcroft	298	20.4	23	c	29
	Local to Pleasant R.	177	12.2	16	c	f
	Sebec R.	352	24.2	17	16	18
	Pleasant R.	334	23.0	28	35	53
	Local to Penobscot R.	293	20.2	16	49	f
		---	----	--	--	--
	Total	1454	100.0	100	100	100

NOTES:

a. Included in West Branch
b. Included in Piscataquis R.
c. Included in Local to Penobscot R.
d. Included in East Branch
e. Included in Local to Eddington
f. Included in Pleasant R.

reservoir levels are relatively high. This was the case in May 1973. Measured flow data for the West Branch is not available, however, based on component watershed contribution analysis, the West Branch and local contribution to the peak Penobscot River flow at West Enfield is estimated at 25 to 35 percent.

The only significant storage available in the East Branch watershed is located in the Telos-Chamberlain Lake and Grand Lake system. The Telos-Chamberlain lake system is located in the headwaters of the East Branch and has a drainage area of 240 square miles. Grand Lake with a drainage area of 484 square miles provides about 41,000 acre-feet of storage. The remainder of the watershed (626 sq. mi.) has little storage and historically has contributed to main stem flood peaks. The East Branch has a total drainage area of 1,120 square miles which represents 17 percent of the drainage area at the West Enfield gage. East Branch's contributions to the peak flow at West Enfield for the 1936 and the 1973 flood events are estimated at 19 and 21 percent, respectively. For the 1987 flood, East Branch's contribution is about 25 percent. Precise contribution of the East Branch could not be determined because the USGS gaging station at Grindstone had been discontinued.

(2) Medway to West Enfield. The net drainage area from Medway to just below the mouth of the Piscataquis River in West Enfield is 3,441 square miles or 40 percent of the total Penobscot River watershed. About 85 percent of this intervening area is contained in the two large tributaries - Mattawamkeag (1,490 sq. mi.) and the Piscataquis (1,454 sq. mi.) Rivers. The principal flood-producing tributary in this reach is the Piscataquis River with lesser contributions coming from the Mattawamkeag River. The Piscataquis River with its 1,454 square mile drainage area represents about 17 percent of the total Penobscot area and 22 percent of the basin above the West Enfield gage. This tributary contributed 53 and 44 percent to the peak floodflow for the 1987 flood at West Enfield and Eddington, respectively. The Mattawamkeag River having nearly the same drainage area as the Piscataquis (1,490 sq. mi.) contributes only 13 and 11 percent, to the peak 1987 floodflow at West Enfield and Eddington, respectively. For the 1936 flood, the Piscataquis and Mattawamkeag contributed approximately 45 and 20 percent, respectively, to the peak floodflow at West Enfield. A cursory review of two other flood events (November 1943 and November 1950) that had been analyzed in the NENYIAC studies shows that the Piscataquis River was one of the most significant contributors to peak floodflows in the basin, representing over 40 percent of the total peak floodflow.

For the 1973 flood, the Piscataquis contributed a much smaller component (approximately 18 percent) of the peak floodflow at West Enfield. The Mattawamkeag contributed nearly the same amount. In most cases, the peak of the Mattawamkeag occurs several days after the peak on the Penobscot. Local drainage from the smaller tributaries in this reach added about 12 percent of the peak flow at West Enfield for the 1936 flood. For the 1973 and 1987 flood, the local contribution is estimated between 10 and 15 percent of the peak flow at West Enfield.

(3) Piscataquis River. Since the Piscataquis River tributary historically has been a major contributor to peak main stem flows, a more detailed hydrologic analysis of this watershed was undertaken. The USGS has recorded streamflow at several locations and for various periods of record within this watershed. Principal gaging stations are Piscataquis River at Dover-Foxcroft (298 sq. mi.), the Sebec River (352 sq. mi.) and the Pleasant River (334 sq. mi.). Results of analysis of flow data at these stations indicate that the Pleasant River and uncontrolled local area are significant contributors to Piscataquis River peak floodflows. The Piscataquis above Dover-Foxcroft is also a significant contributor for the size of its drainage area, however, peak flows from this area tend to be somewhat delayed and historically has not been a major contributor to the peak flow at the mouth. The Sebec River with a relatively large amount of storage for the size of its watershed, has been a lesser contributor to main stem peaks. Hydrograph analysis and contribution to flood peaks for the 1936, 1973 and 1987 flood events are shown graphically on plates 4, 5, and 6, respectively.

(4) West Enfield to Bangor. The net drainage area from West Enfield to Bangor Water Works Dam (partially breached, DA = 7,830 sq.mi.) is 1,159 square miles or 13 percent of the total basin area. The largest tributary in this area is the Passadumkeag River (DA = 385 sq. mi., 4 percent of the total basin area). This watershed, however, is quite sluggish and historically has not been a major contributor to peak floodflows. The Bangor Water Works Dam, prior to its breaching, was the upper limit of the tidewater with an estimated mean tide range of 13.5 feet. Contributions to peak Penobscot flows from the net drainage area (1,159 sq. mi.) have been relatively minor. For the most part, peak Penobscot River floodflows in this reach are the result of runoff above West Enfield.

10. FLOOD CONTROL ALTERNATIVES

a. General. Thirty-two stage frequency curves were determined at 14 developed areas along the Penobscot and Piscataquis Rivers in order to assess economic feasibility of flood reduction schemes. Representative curves are shown on plates 3A and 3B.

b. Flood Control Reservoirs.

(1) NENYIAC Identified Sites. As part of the NENYIAC studies for the Penobscot River, flood protection was investigated assuming construction of selected single purpose flood control reservoirs. At that time it was determined there were insufficient damages available to justify construction of any reservoir strictly for flood control purposes.

A series of multipurpose hydropower storage projects were then considered which would have provided incidental flood reductions. However, allocation of storage strictly for flood control at these projects could not be justified at that time. These storage projects with pertinent data are listed in table 10. For information purposes, river profiles as taken from the NENYIAC studies are shown on plates 7A through 7F.

From analysis completed for the NENYIAC report, it was determined that for a recurring flood of the 1936 magnitude, there would be a reduction in the peak discharge of approximately 10 percent if the three East Branch projects were in place, 20 percent if the Stratton Rips project was in place, and approximately 29 percent if both the East Branch and Stratton Rips projects were in place. These reductions would result in a lowering of the peak stages on the Penobscot River at West Enfield by about 1.5 feet, 2.5 feet, and 3.5 feet, respectively.

A description of those hydropower projects which would provide some incidental flood control storage is provided below. This cursory information is included only to give an indication of the magnitude of potential reductions by utilizing these sites for flood control alone. It is noted that no detailed indepth hydrologic studies were conducted to assess flood reductions attributable to these storage sites.

(a) Allagash Lake. This site, with a drainage area of 79 square miles, is on Allagash Stream approximately one-half mile below the outlet of Allagash Lake. The structure would consist of a 780 foot long dam with a maximum

TABLE 10

PENOBSCOT RIVER BASIN
NENYIAC PLAN OF POWER DEVELOPMENT

Project	Type	Useable Storage In Ac. Ft.	Drainage Area In Sq. Mi.
	EAST BRANCH PENOBSCOT RIVER		
Allagash Lake	Storage	32,500	79
(Diversion) Grand Lake-Sawtelle Falls	Power & Storage	181,900	548
Whetstone Falls	Power & Storage	152,000	985
	MATTAWAMKEAG RIVER		
Stratton Rips	Power & Storage	863,000	1,484
	PISCATAQUIS RIVER		
Bonnie Brook	Power & Storage	57,400	1,254

height of 25 feet. The project would raise the present level of Allagash Lake by approximately 8 feet to an elevation of 1,045 feet NGVD and thereby make available 32,500 acre-feet (7.7 inches of runoff) of storage capacity with a drawdown of 7.5 feet.

(b) Grand Lake - Sawtelle Falls. This proposed dam was an extensive power development on the East Branch at the location of an existing dam at First Grand Lake, drainage area of 548 square miles. The proposal would have involved raising the existing First Grand Lake dam, adding a 2,000 foot long earth dike, a canal and construction of an additional dam 55 feet high and 300 feet long with a powerhouse at Sawtelle Falls. This complex reservoir system would have provided a total usable storage capacity of 181,900 acre-feet (6.2 inches of runoff).

(c) Whetstone Falls. This site is on the East Branch Penobscot River 12 miles upstream of the village of Grindstone and 2 miles below the mouth of Wassataquoik Stream. The drainage area at the site is approximately 985 square miles. The dam at this location would have an overall length of 5,300 feet, including 4,840 feet of rolled earth-fill, and a 330 foot gate-controlled concrete spillway. The dam would have a maximum height of 145 feet and would have 156,000 acre-feet (2.9 inches) of usable storage. It's noted that 2.9 inches of storage is not adequate to contain major floods and additional storage capacity for flood control would be required.

(d) Stratton Rips. The site of this project, with a drainage area of 1,484 square miles, is on the Mattawamkeag River 2.4 miles above its mouth. The dam would be of earth-fill and concrete construction and have a length of approximately 8,500 feet and a height, above the present river channel, of 160 feet. Six earth dikes, with a combined length of 16,600 feet would be required to close saddles in the rim of the reservoir. The project would have storage capacity of 863,000 acre-feet equivalent to 10 inches of runoff.

(e) Bonnie Brook. The site of this development is on the Piscataquis River 8.4 miles above its mouth at the Penobscot River at Howland, Maine. It has a drainage area of 1,254 square miles. The dam would have a total length of 2,500 feet and a maximum height of 100 feet. A total storage capacity of only 57,400 acre-feet (0.8 inches of runoff) would be available and would not have an appreciable effect on major floodflows.

Table 11 presents pertinent data on the described hydropower storage projects that were analyzed in the NENYIAC report and showed the highest flood reduction potential. For this investigation, however, it is assumed that each project is operated solely for flood control and the size of the project is based only on that needed to provide 6 inches of storage, where possible, from the contributing drainage area. A cursory estimate of the impact on stage reductions for a recurrence of a storm the magnitude of the April 1987 event is also shown in the table.

(2) Piscataquis River Reconnaissance Sites. In addition, as part of this study, a small number of potential flood control sites in the Piscataquis River basin were investigated. The Piscataquis basin was chosen for several reasons; 1) it was the hardest hit in the Penobscot River basin during the 1987 flood, 2) it is the largest contributor to peak flood conditions of the populous lower stem of the Penobscot River, and 3) it has large uncontrolled drainage areas.

Engineering judgment was used to screen the sites for this reconnaissance study. Criteria considered are as follows: 1) the reservoir should be located in a largely undeveloped area, and 2) the proposed dam should be as small as possible and provide for a reservoir having the capability to store at least 6 inches of runoff from the contributary drainage area.

Locations evaluated included four sites; namely, East Branch Piscataquis River in the town of Blanchard (DA = 114 sq. mi.) and Kingsbury Stream in the town of Abbot (DA = 93 sq. mi.); Big Wilson Stream in the town of Willimantic (DA = 69 sq. mi.); and the East Branch Pleasant River above Brownville (DA = 100 sq. mi.). Table 11 presents the results of the cursory analysis and estimated reductions to flood stages for a recurrence of the April 1987 event.

The U.S. Soils Conservation Service (SCS) is also evaluating potential flood control reservoir sites in the Piscataquis River basin. Although current data provided by SCS indicates that one site may be justified, their investigation is in the preliminary stages and only limited data is available.

c. Structural - Local Protection Plans. Of the areas investigated, there were four structural flood reduction projects identified as having the potential for economic justification. This was based on the density of flood-prone properties in these areas and the frequency of flooding.

TABLE 11

FLOOD CONTROL RESERVOIRS

Location	Drainage Area (sq. mi.)	Storage Capacity (Ac.-Ft.)	---Dam--- Length of Crest (Feet)	Height (Feet)	Effect on Downstream Flood Stages for Recurrence of 1987 Flood Event (in Feet) Piscataquis River Gilford	Dover	Milo	Howland	Penobscot River West Enfield
PISCATAQUIS RIVER									
1. East Branch Piscataquis River and Blanchard	114	36,500	2,400	75	Red. 6-7	Red. 4-5	Red. 5-6	Red. <0.5	Red. <0.3
2. Kingsbury Stream at Abbott (Tributary of Sebec River)	93	30,000	800	110	Red. 5-6	Red. 5-6	Red. 3-4	Red. <0.5	Red. <0.3
3. Big Wilson Stream at Willimantic (Tributary of Sebec River)	69	22,100	2,300	110	NR	NR	Red. 3-4	Red. <0.5	Red. <0.3
4. East Branch Pleasant River above Brownville	100	32,000	1,300	50	NR	NR	Red. 4-5	Red. <0.5	Red. <0.3
EAST BRANCH PENOBSCOT									
5. Allagash Lake	79	25,300	710	23	NR	NR	NR	NR	Red. <0.3
6. (Diversion) Grand Lake-Sawtelle Falls	548	175,400	300	55	NR	NR	NR	NR	Red. 1.5 - 2.0
7. Whetstone Falls	985	152,300 (3" of Runoff)	5,300	135	NR	NR	NR	NR	Red.* 1.5 - 2.0
MATTAWAMKEAG RIVER									
8. Stratton Rips	1484	474,900	8,000	140	NR	NR	NR	NR	Red. 1.5 - 2.0

NOTES: a. Locations 5 through 8 are from the NENYIAC studies completed in 1954. The project size was reduced if possible to enable the control of 6" of runoff with no provision made for power purposes. Those sites where storage of runoff less than 6" are noted.

b. Reductions claimed are considered the upper limit obtainable and further study would be required to quantify the effectiveness of the Whetstone Falls project.

c. NR means no reduction in stage from existing conditions.

Three are on the Piscataquis River and one on the Penobscot River. They are briefly described in the following paragraphs. More detail is given in the main report.

(1) Piscataquis River

(a) Guilford. The project envisioned would be construction of a hinged gate on the existing Guilford Dam on the Piscataquis River. To prevent flooding from the river downstream of the dam, an additional dike with a possible street gate across Water Street would be needed. These improvements would protect a factory, and commercial structures along Main Street and Water Street.

(b) Dover-Foxcroft. This project would consist of a low dike along the north bank of the Piscataquis River just upstream of the Pleasant Street bridge in Dover-Foxcroft. This would prevent flooding to residential and commercial structures along South Street.

(c) Howland. A low dike would be located on the north side of the Piscataquis River in Howland just above its confluence with the Penobscot River. This structure would prevent flooding to commercial and residential structures along Water Street, Davis Street and Front Street.

(2) Penobscot River

(a) Bradley. This project would consist of a dike to protect residential structures in the town of Bradley near the confluence of Otter Stream with the Penobscot River. The dike would have to front both the Penobscot River and Otter Stream.

d. Non-Structural Flood Warning. A flood warning system (by Planning Division and described in the main report) has been evaluated as a component of non-structural flood reduction measures. Flood development in the Penobscot basin is complex, varying on areal extent of rainfall and antecedent conditions. Many of the smaller tributaries can produce rapid runoff resulting in localized flooding. Estimated warning times for use in reconnaissance level studies are listed below. Warning times were determined based on the time difference between relatively high initial riverflow to time of estimated flood-flow for the historic floods analyzed. The high initial flow was assumed to be the estimated 50 percent chance (2 year) flow and the floodflows are defined for this purpose as those having a 10 percent chance (10 year) of occurrence.

River	Location	Estimated Warning Time
Piscataquis	at Dover-Foxcroft	6 to 12 hours
	at Medford	12 to 18 hours
	at Howland	18 to 24 hours
Penobscot	at West Enfield	24 to 30 hours
	at Bangor	24 to 36 hours

11. SUMMARY AND CONCLUSIONS

The Penobscot River basin is subject to both frequent and major flooding as a result of joint occurrences of meteorological events, i.e., coincident rainfall with snowmelt, successive rainfall events, or intense rainfall.

Total storage in the Penobscot basin amounts to approximately 1,570,000 acre-feet with over 80 percent located in the West Branch Penobscot watershed and the majority of the remainder in the East Branch Penobscot and the Piscataquis River. As a result of the large amount of storage in the West Branch Penobscot watershed, equivalent to about 12 inches of runoff from the 2,110 square mile basin, historically there has been very little contribution to the peak flows of the Penobscot River (less than 5 percent of the flow for the March 1936 and April 1987 storms). However, there have been infrequent floods, notably April 1973, during which the West Branch contributions were more significant. Another tributary of the upper watershed, the East Branch Penobscot, has little storage available and generally contributes more to flood peaks. Contributions range from 15-20% of the peak on the lower Penobscot.

Two other tributaries in the central part of the basin contribute significantly to peak flows on the Penobscot River. These are the Mattawamkeag River and the Piscataquis River. The 1,490 sq. mi. Mattawamkeag River watershed makes up nearly 17 percent of the basin and generally contributes a similar amount to peak floodflows on the lower Penobscot. Due to its hydraulic characteristics, however, floodflows from this watershed generally peak several days after the peak on the lower Penobscot.

The 1,454 sq. mi. Piscataquis River, although comprising only 17 percent of the basin, provides significant peak floodflows during most of the major flood events, generally in the 45 to 55 percent range of the floodflows recorded at the West Enfield gage. It should be noted that 1973 flood apparently occurred at a time of high initial levels within the large upstream storage reservoirs. Therefore, a high percentage of floodflow was made up of runoff from the West Branch Penobscot River with lesser contributions from the Piscataquis River.

Flood control reservoirs, if cost effective, would prove most effective in the Piscataquis River watershed and also in the East Branch Penobscot and Mattawamkeag River watersheds.

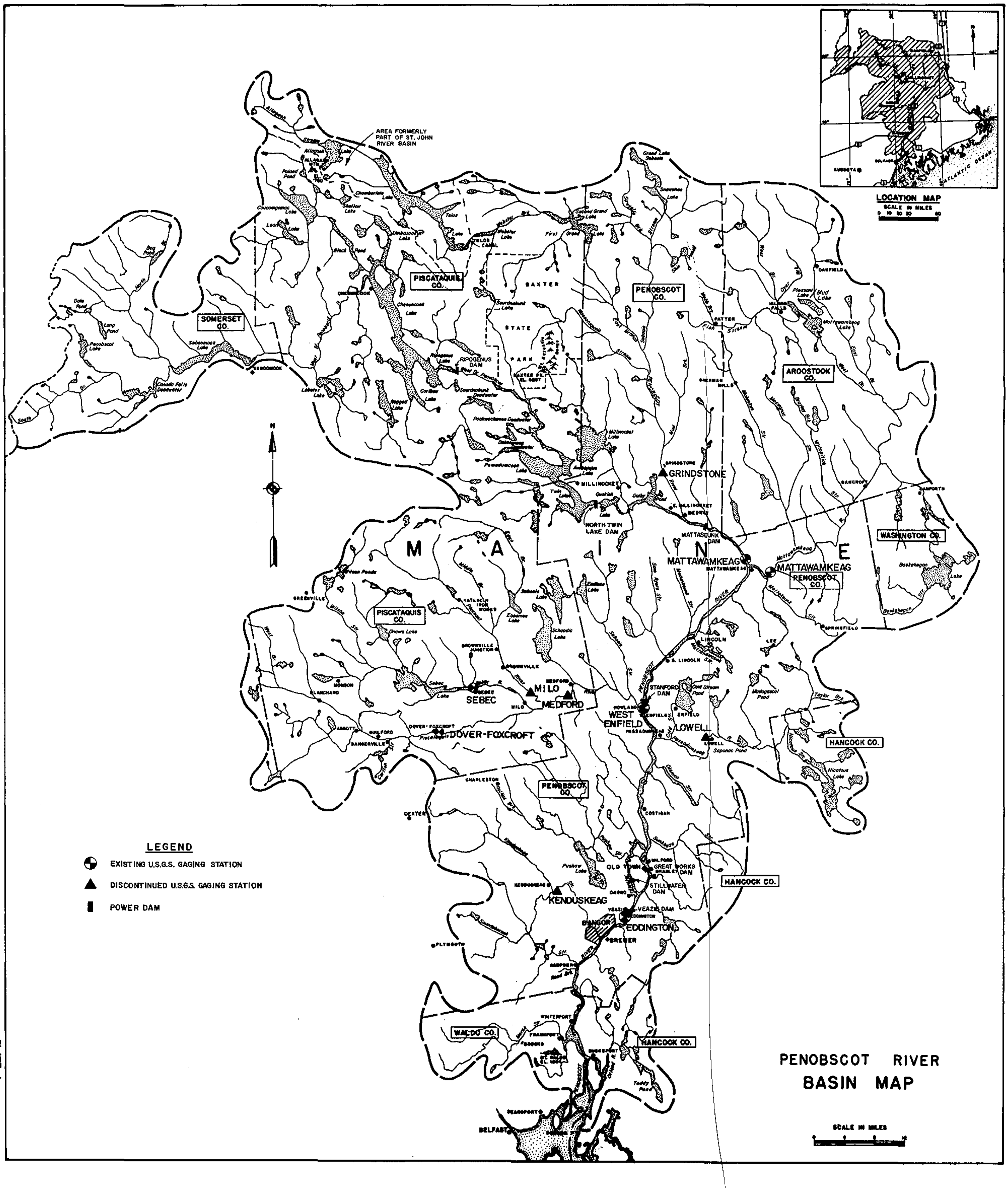
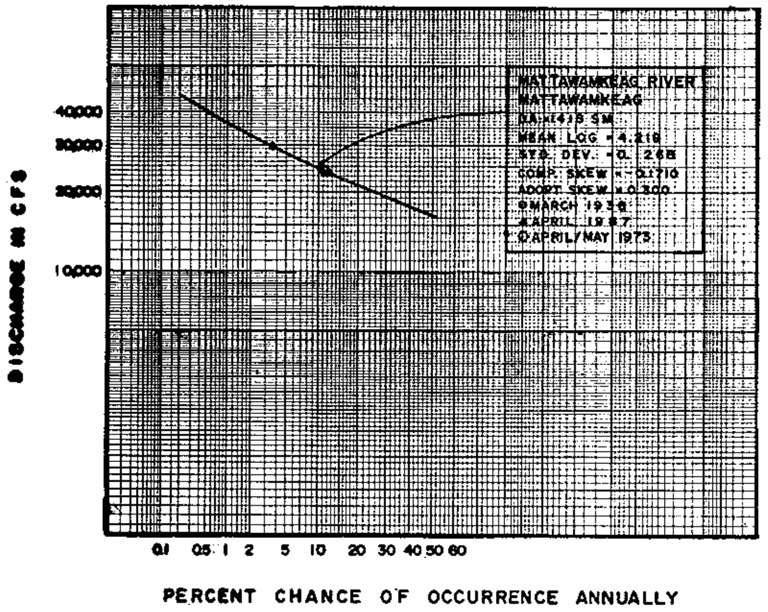
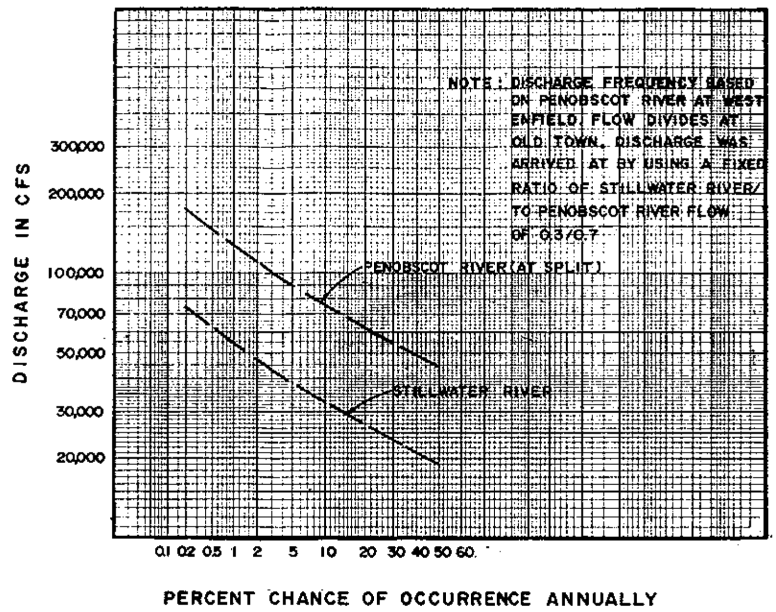
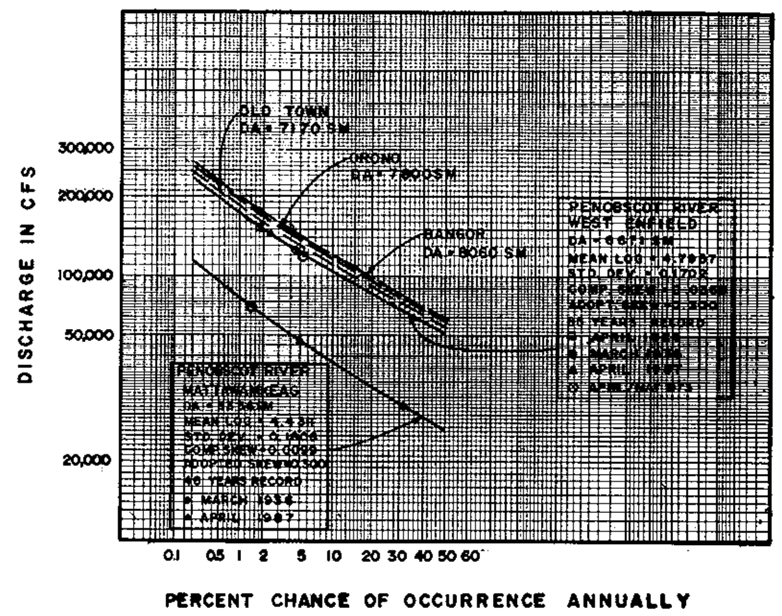
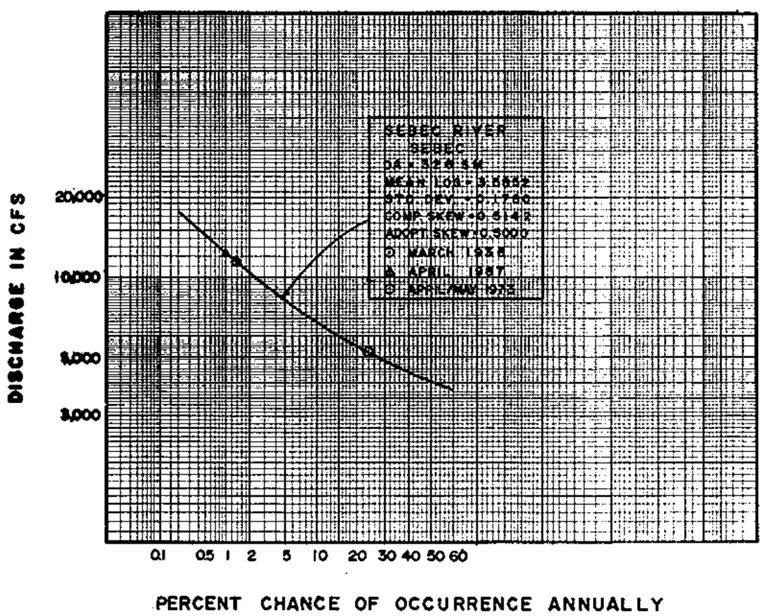

LOCATION MAP
SCALE IN MILES
ATLANTIC OCEAN
AREA FORMERLY PART OF ST. JOHN RIVER BASIN
SOMERSET CO.
PISCATAQUIS CO.
PENOBSCOT CO.
AROOSTOOK CO.
WASHINGTON CO.
HANCOCK CO.
WALDO CO.
BAXTER STATE PARK
RIPOGENUS DAM
GRINDSTONE
MILLINOCKET
NORTH TWIN LAKE DAM
MATTASEUNK DAM
MATTAWAMKEAG
M A I N E
SEBEC
MILO
MEDFORD
DOVER-FOXCROFT
STANFORD DAM
WEST ENFIELD
LOWELL
KENDUSKEAG
OLD TOWN
GREAT WORKS DAM
STILLWATER DAM
VEAZIE DAM
BANGOR
EDDINGTON
BREWER
BELFAST
LEGEND
EXISTING U.S.G.S. GAGING STATION
DISCONTINUED U.S.G.S. GAGING STATION
POWER DAM
PENOBSCOT RIVER
BASIN MAP
SCALE IN MILES

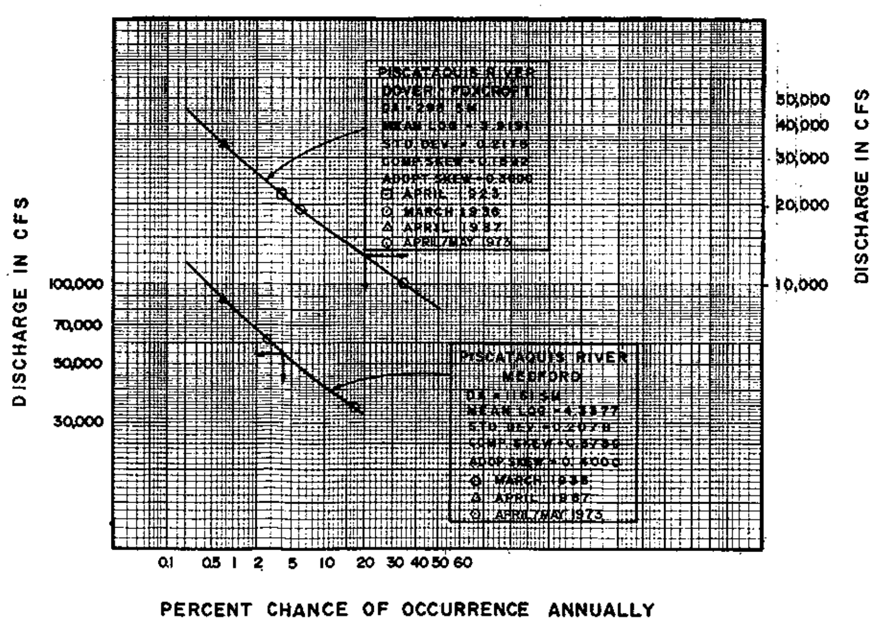
PLATE I











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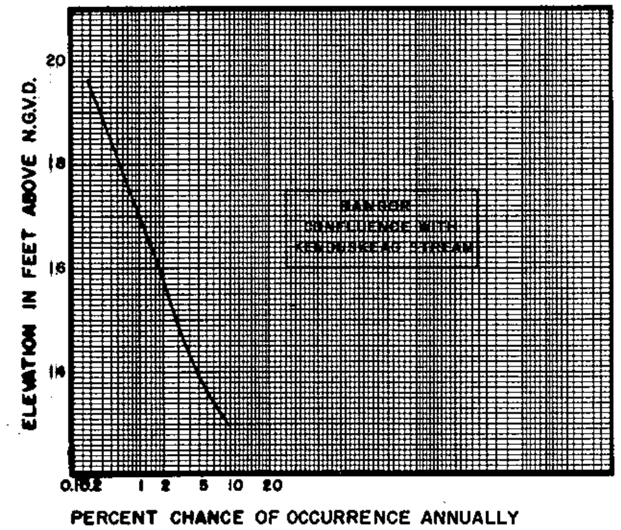
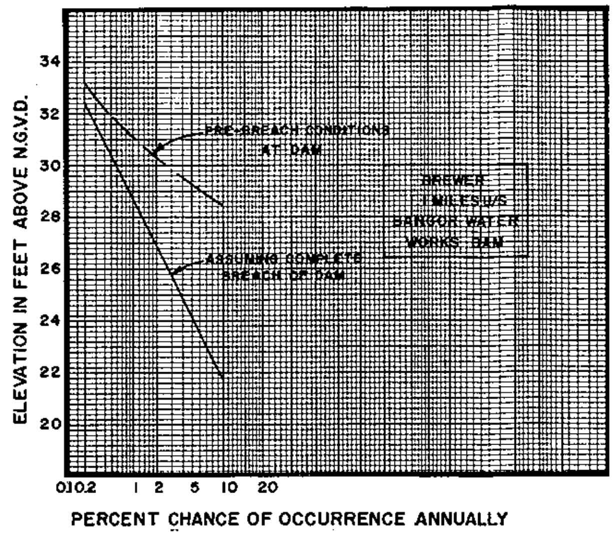
PENOBSCOT RIVER BASIN

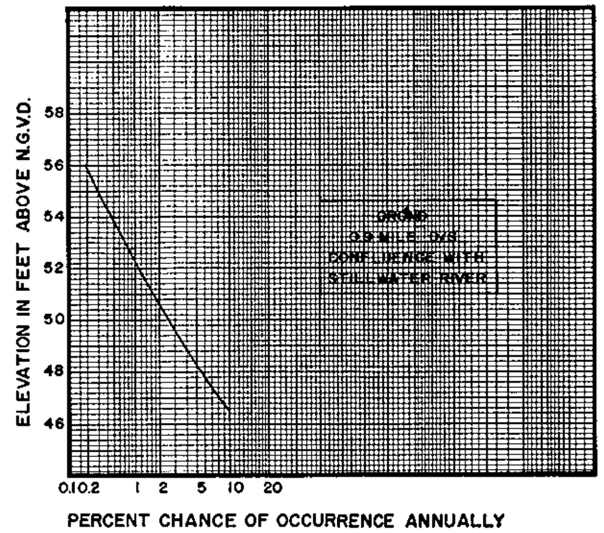
PEAK DISCHARGE FREQUENCY CURVES

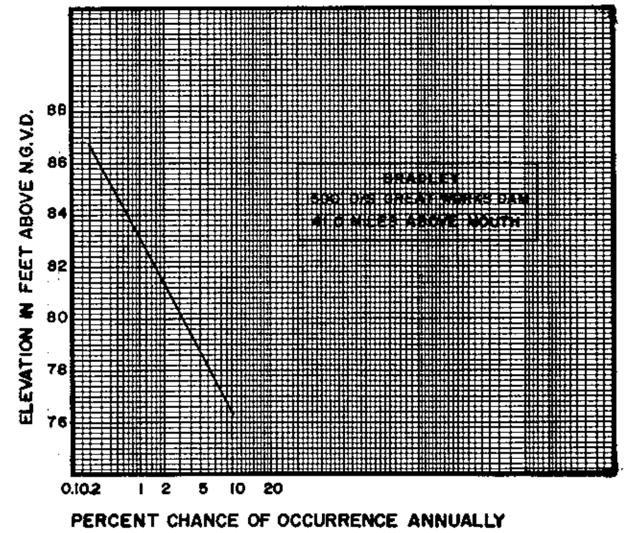
HYDRO. ENGR. SECT. MARCH 1980

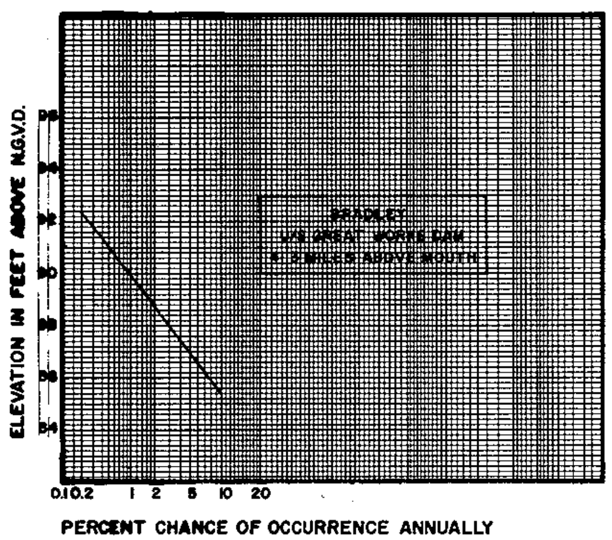
PLATE 2

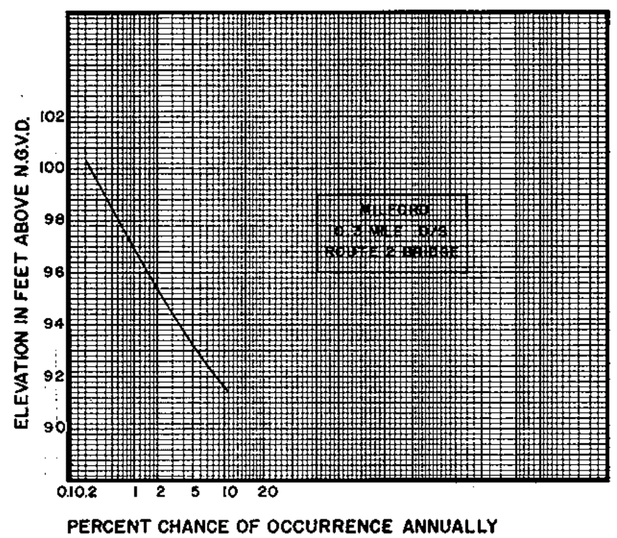


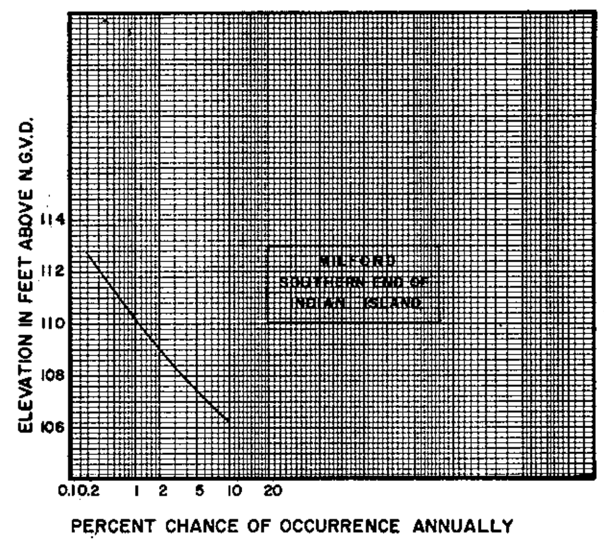


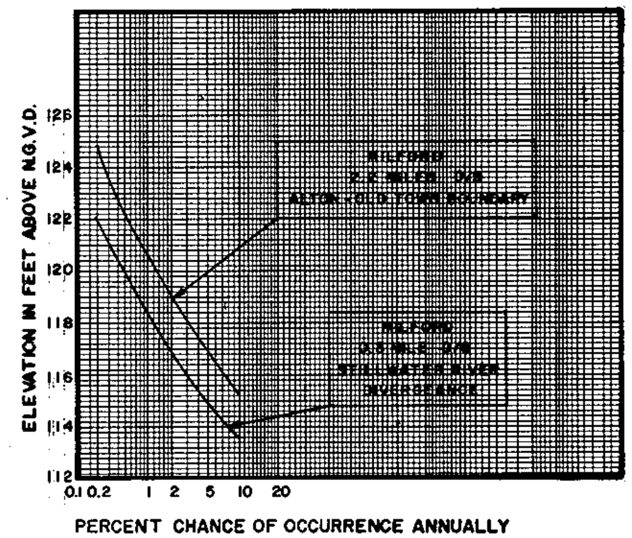


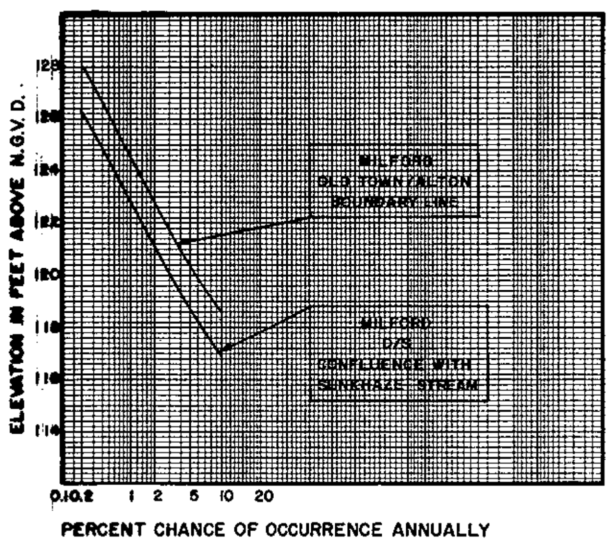


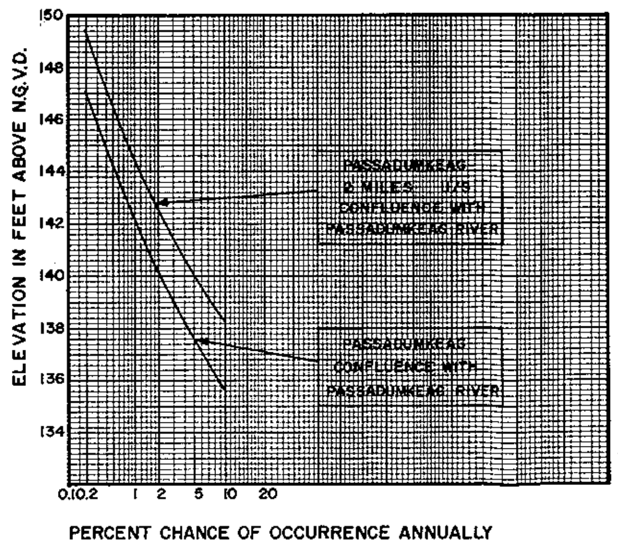












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PENOBSCOT RIVER BASIN

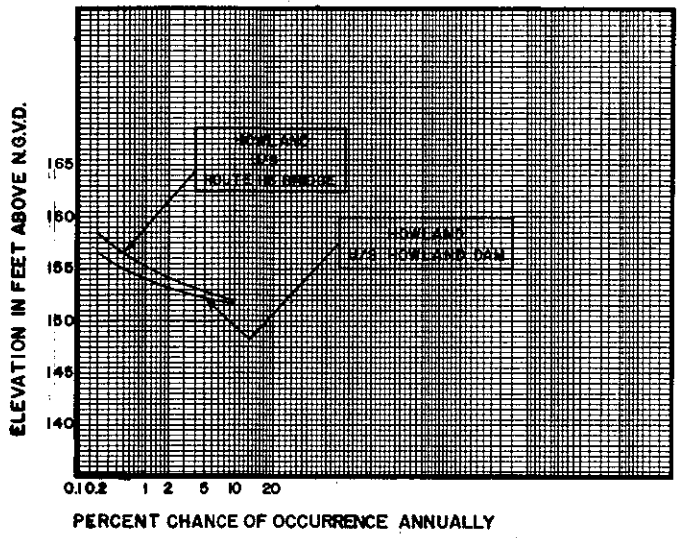
MAINE

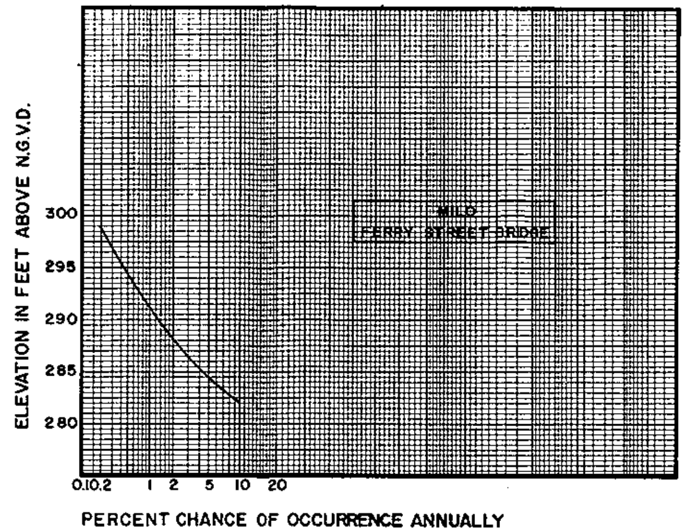
MAIN STEM PENOBSCOT

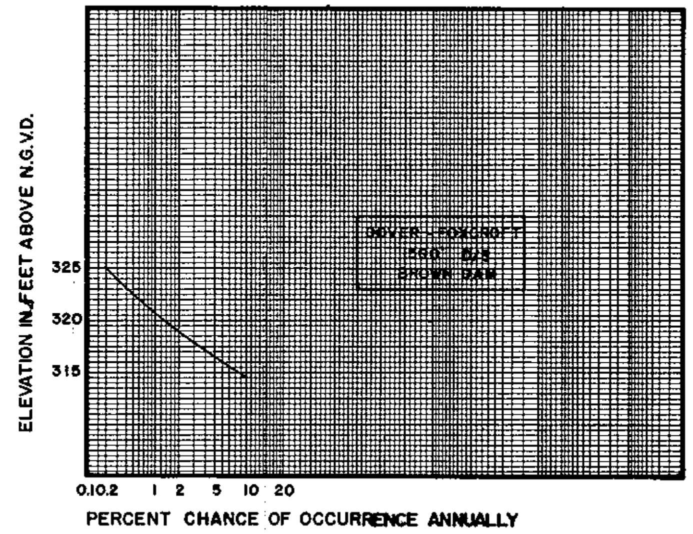
STAGE FREQUENCY CURVES

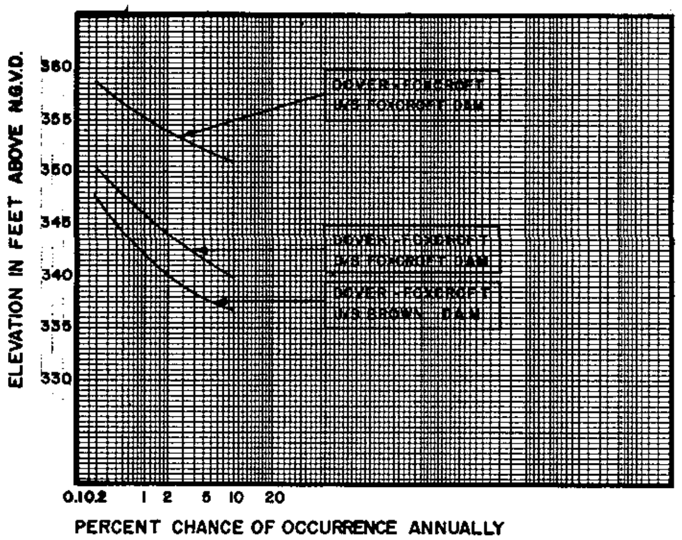
HYDRO. ENGR. SECT. | APRIL, 1989

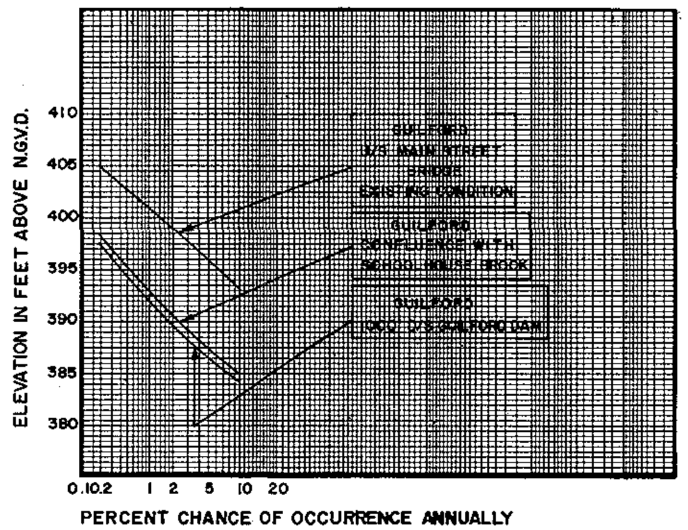
PLATE 3A

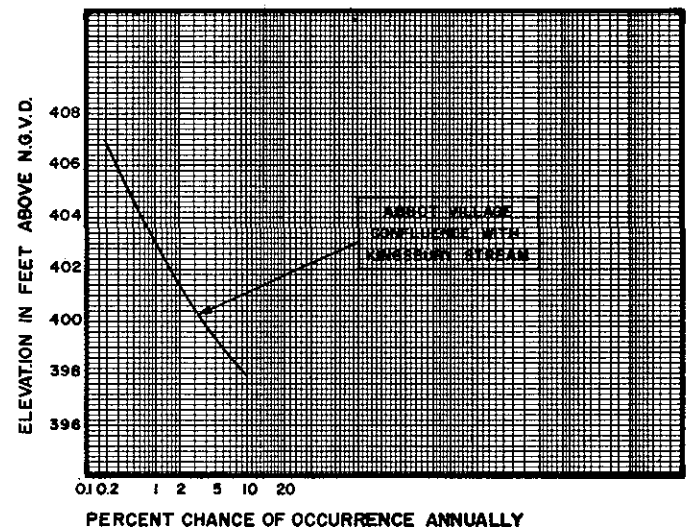


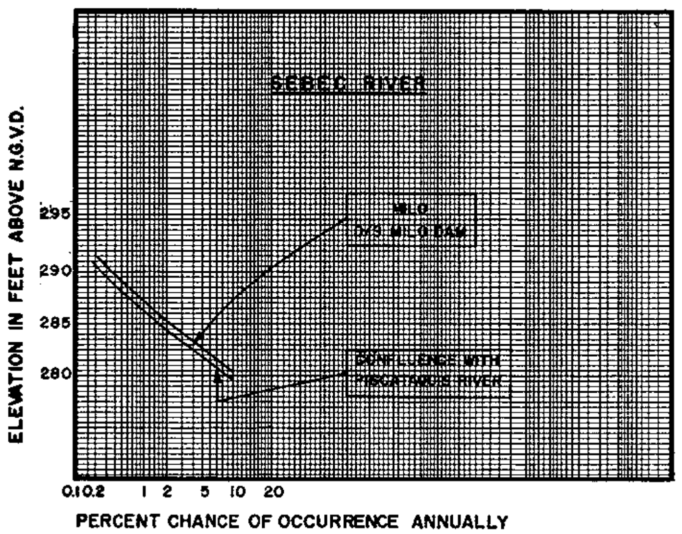












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PENOBSCOT RIVER BASIN

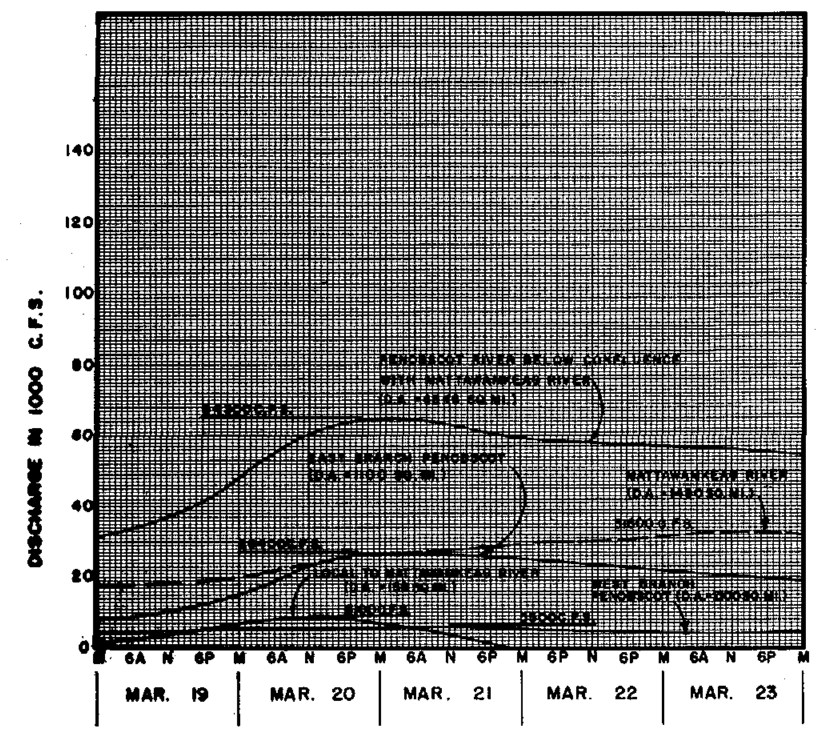
MAINE

PISCATAQUIS RIVER SUBBASIN

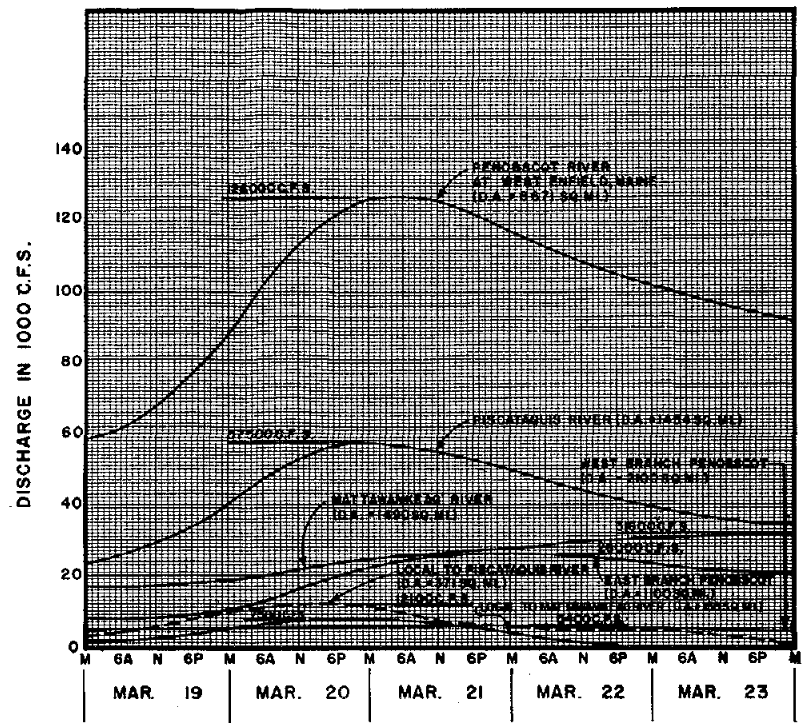
STAGE FREQUENCY CURVES

HYDRO. ENG. SECT. APRIL 1969

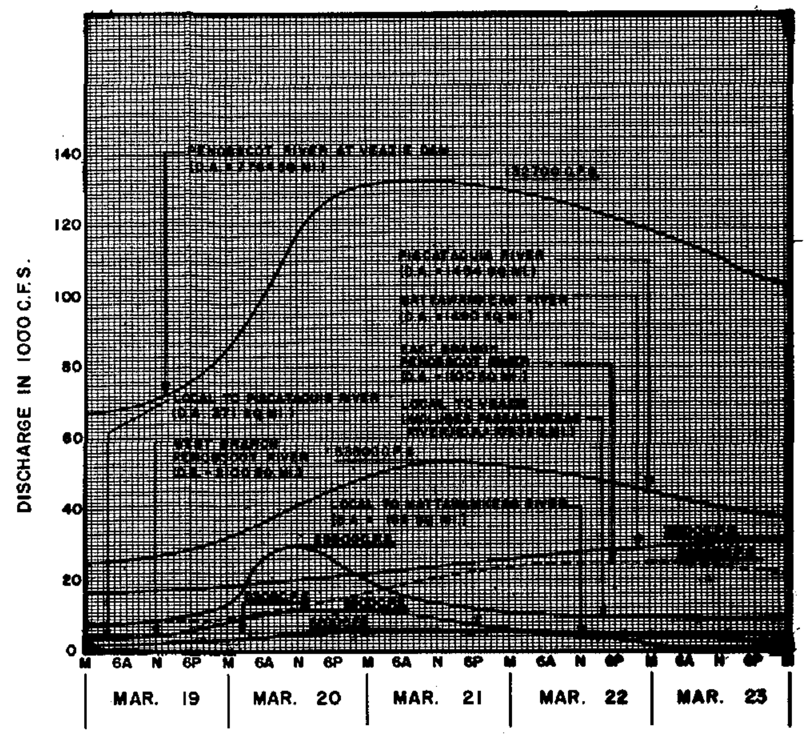
PLATE 3B



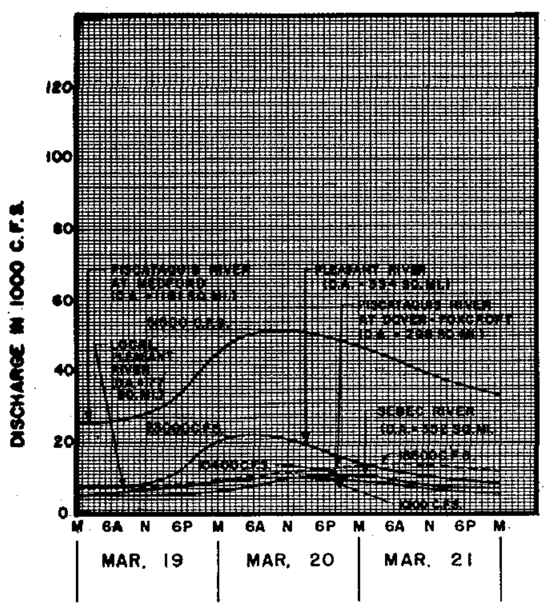
PENOBSCOT RIVER AT MATTAWAMKEAG, MAINE



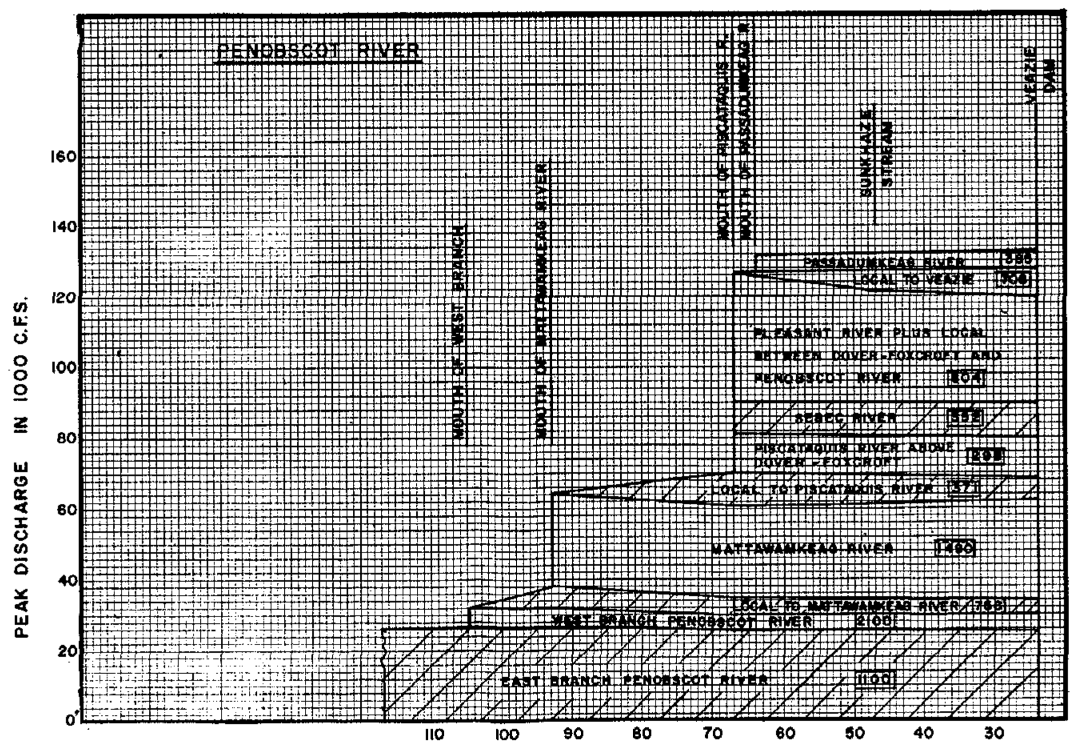
PENOBSCOT RIVER AT WEST ENFIELD, MAINE



PENOBSCOT RIVER AT VEAZIE DAM



PISCATAQUIS RIVER AT MEDFORD



MILES ABOVE TURNER POINT

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PENOBSCOT RIVER BASIN

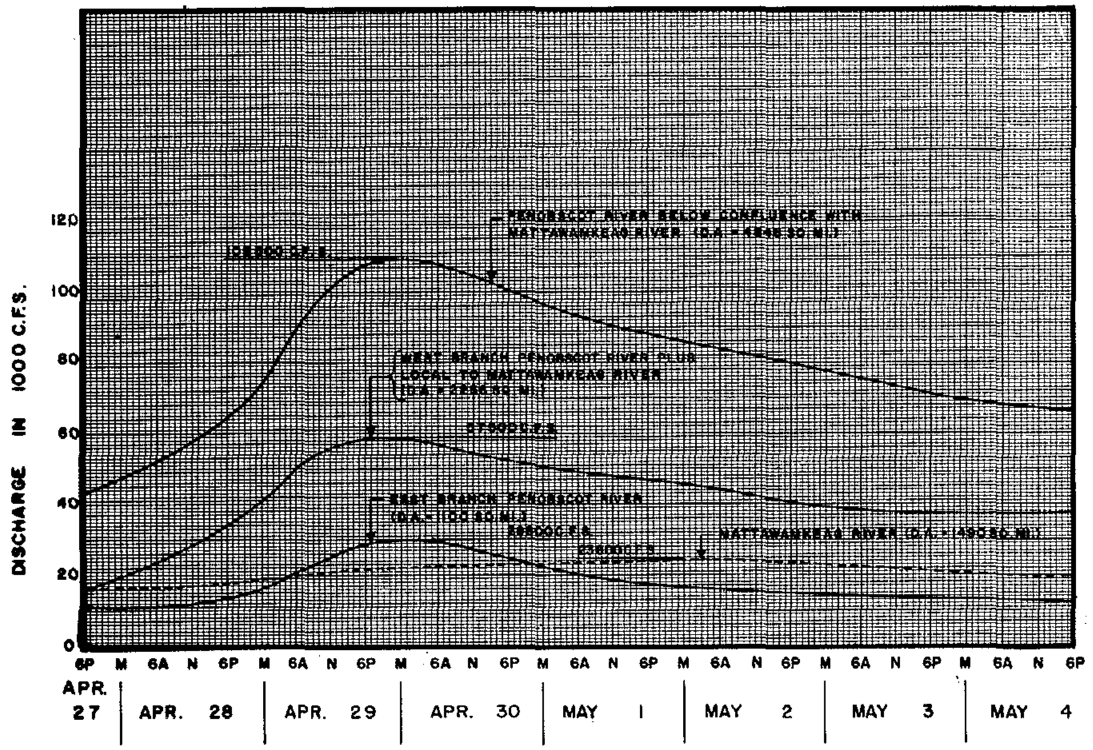
MARCH 1936 FLOOD

FLOOD HYDROGRAPHS AND

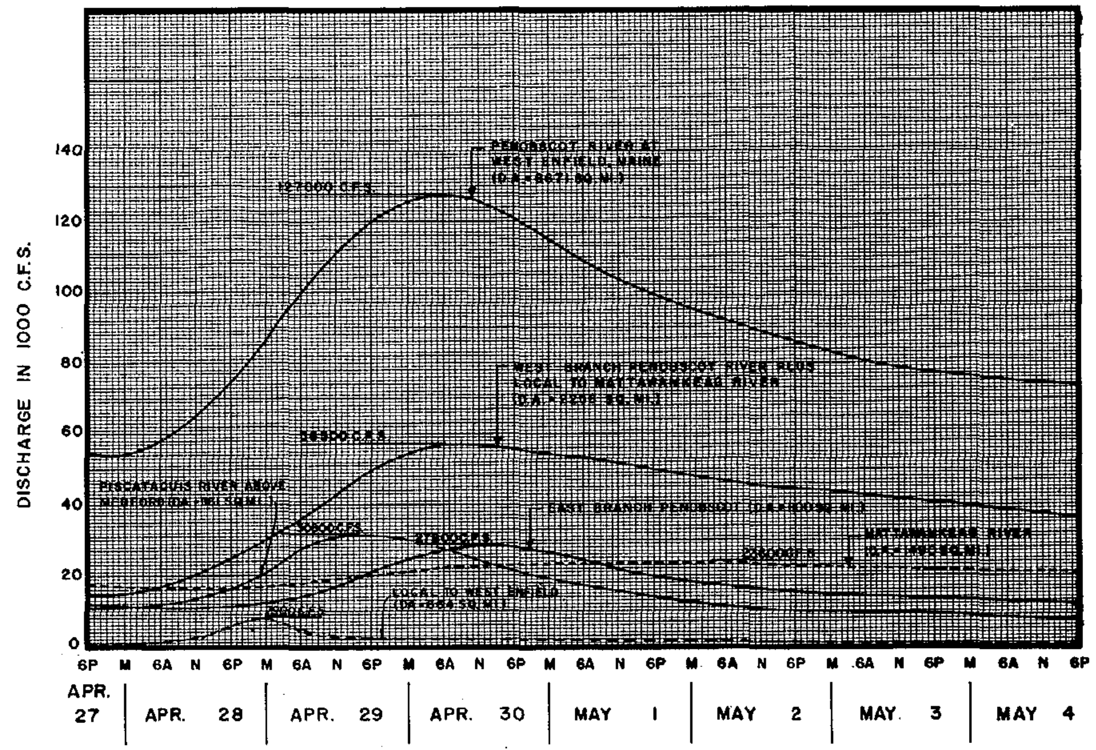
TRIBUTARY CONTRIBUTIONS

HYDRO. ENG. SECT. MARCH 1960

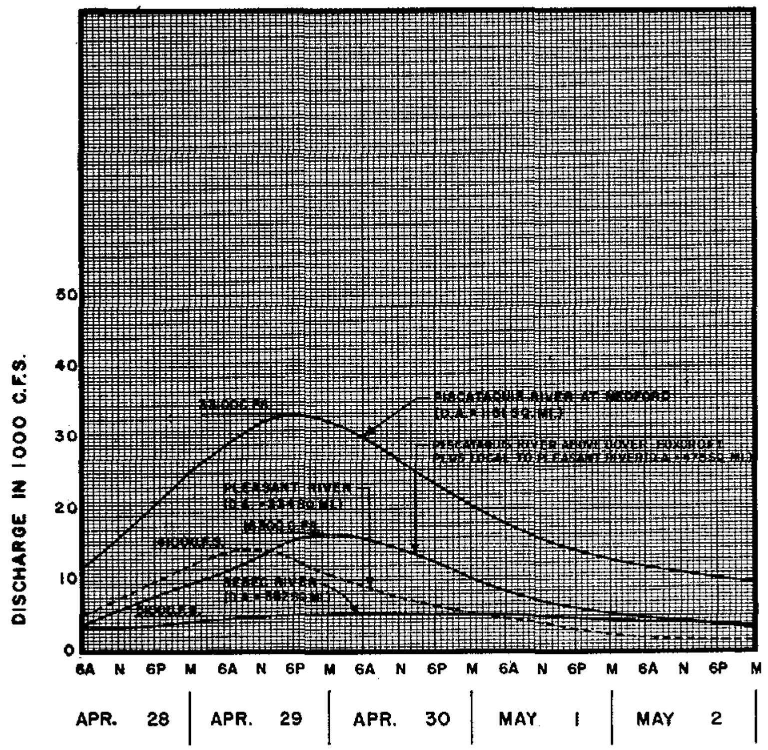
PLATE 4



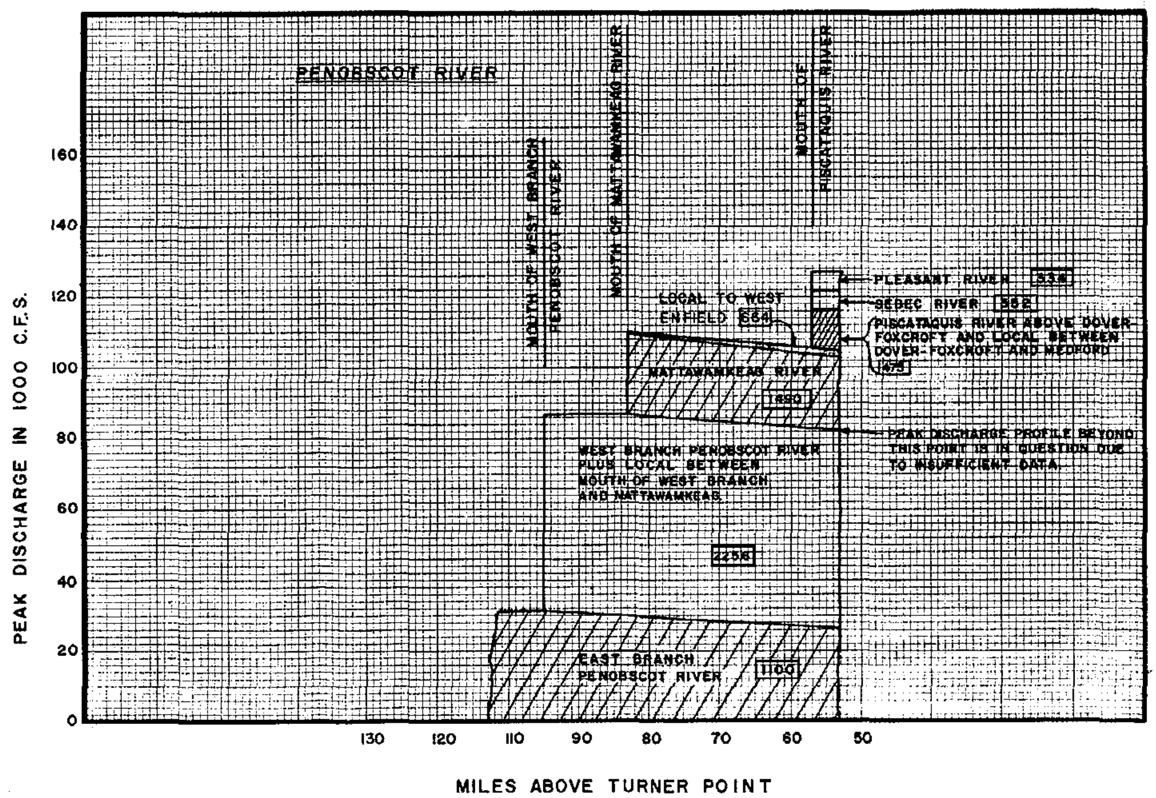
PENOBSCOT RIVER AT MATTAWAMKEAG



PENOBSCOT RIVER AT WEST ENFIELD



PISCATAQUIS RIVER AT MEDFORD



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PENOBSCOT RIVER BASIN

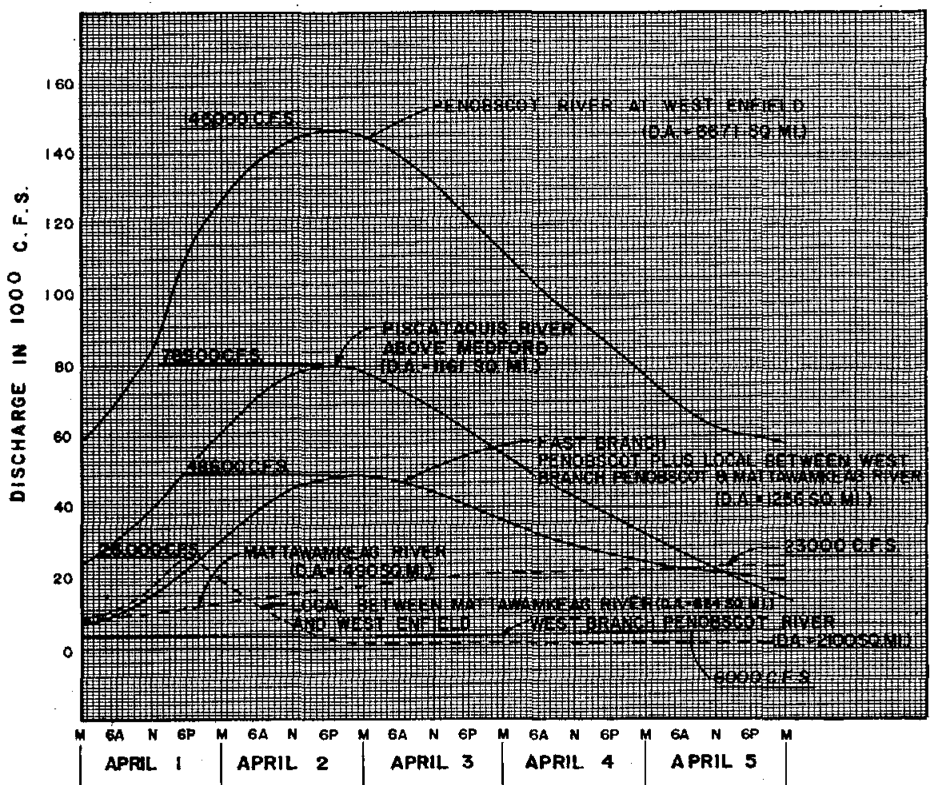
APRIL - MAY 1973 FLOOD

FLOOD HYDROGRAPHS AND

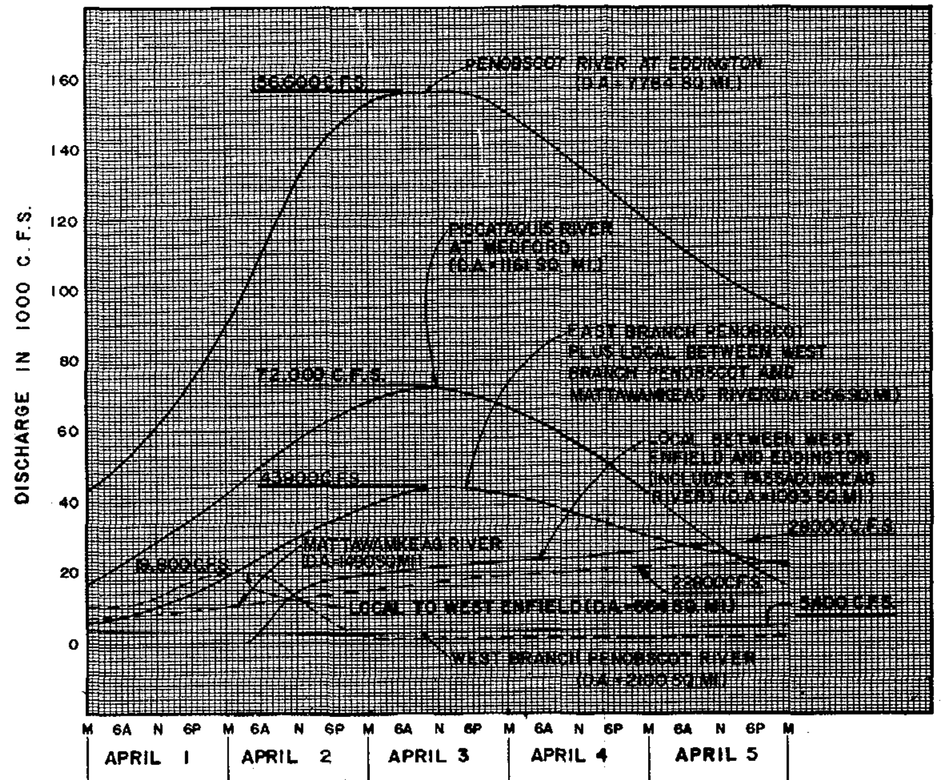
TRIBUTARY CONTRIBUTIONS

HYDRO. ENG. SECT. MARCH 1980

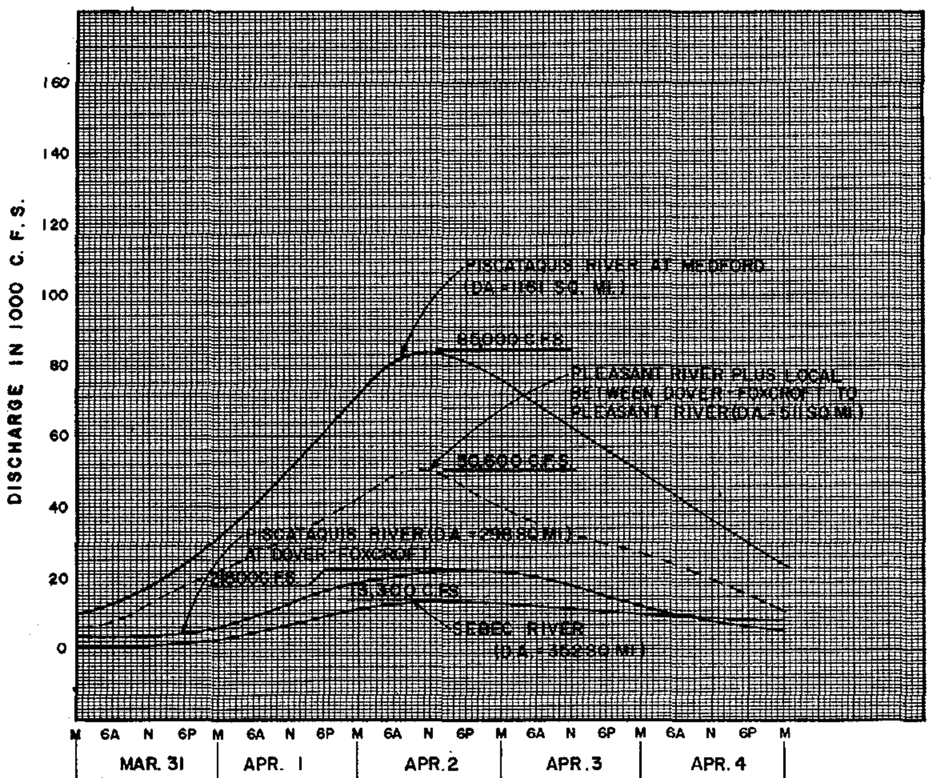
PLATE 5



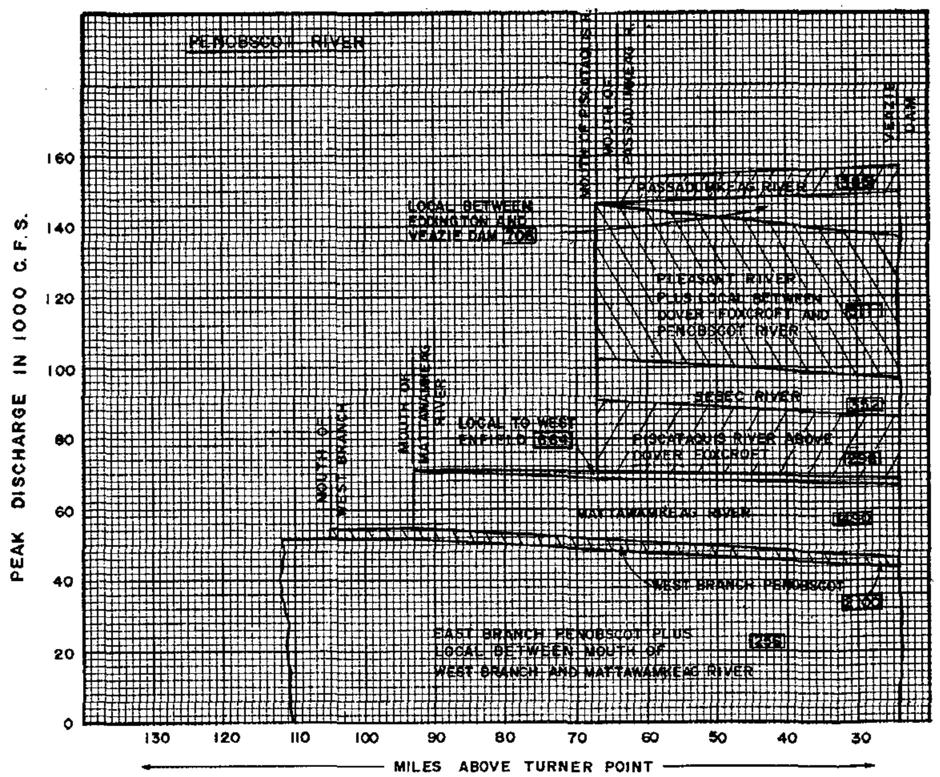
PENOBSCOT RIVER AT WEST ENFIELD



PENOBSCOT RIVER AT EDDINGTON



PISCATAQUIS RIVER AT MEDFORD



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PENOBSCOT RIVER BASIN

MARCH-APRIL 1987 FLOOD

FLOOD HYDROGRAPHS AND TRIBUTARY CONTRIBUTIONS

HYDRO. ENGR. SECT. MARCH 1989

PLATE 6

NOTES

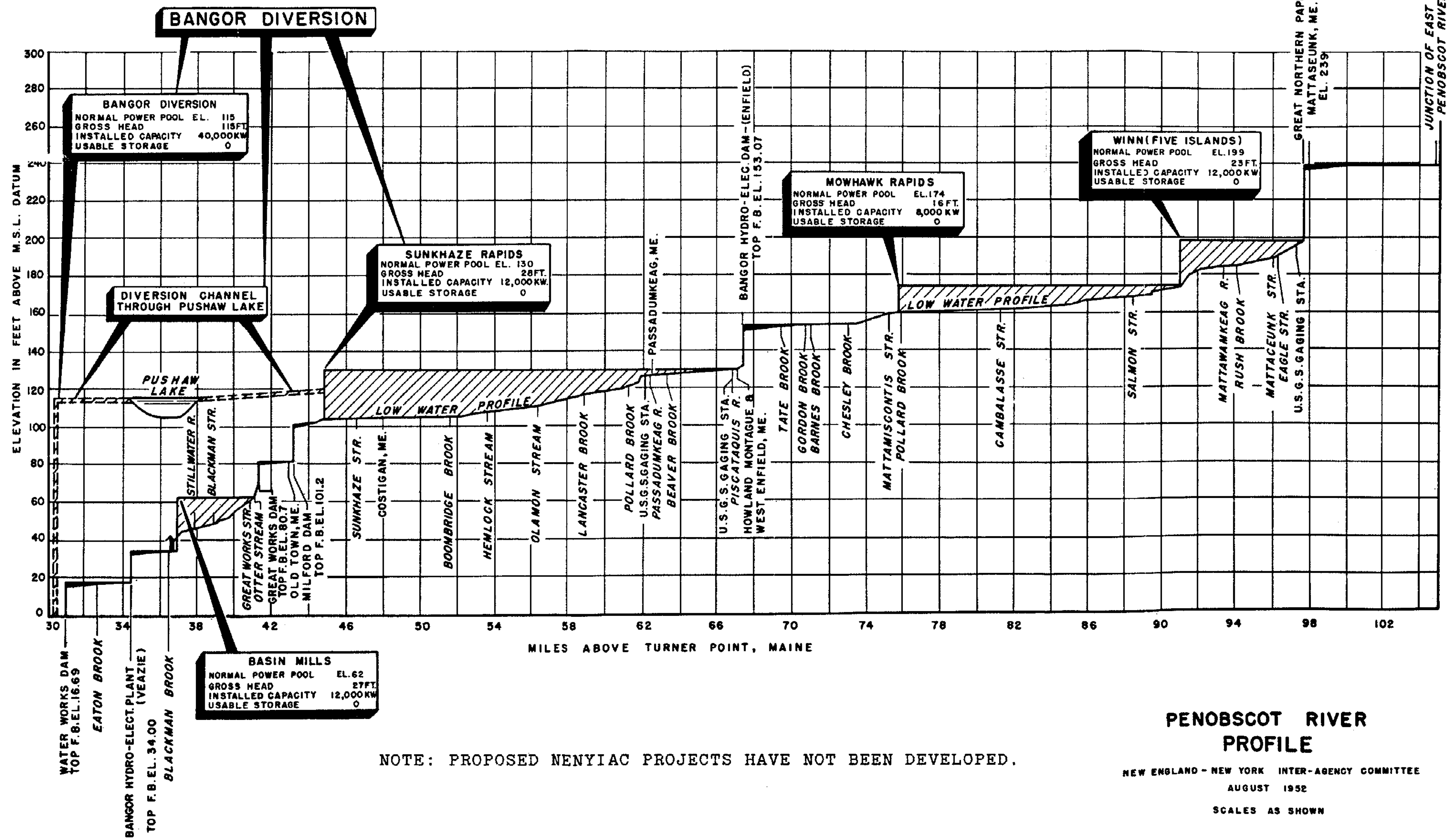
ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL DATUM.

LEGEND

PROPOSED POWER AND STORAGE DEVELOPMENT

EXISTING DEVELOPMENT

F. B. FLASH BOARD



NOTE: PROPOSED NENYIAC PROJECTS HAVE NOT BEEN DEVELOPED.

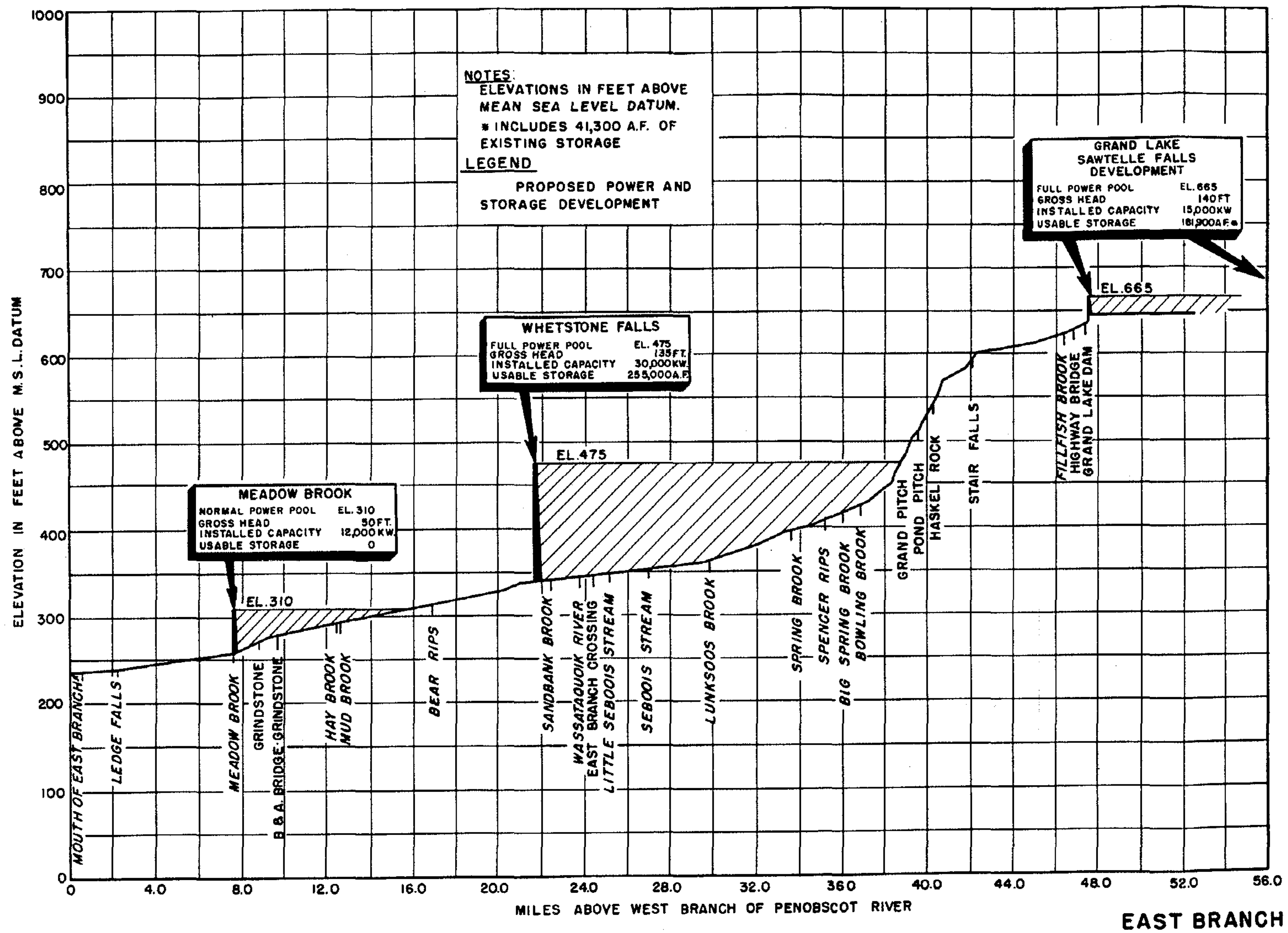
PENOBSCOT RIVER PROFILE

NEW ENGLAND - NEW YORK INTER-AGENCY COMMITTEE

AUGUST 1952

SCALES AS SHOWN

PLATE 7A



EAST BRANCH PENOBSCOT RIVER

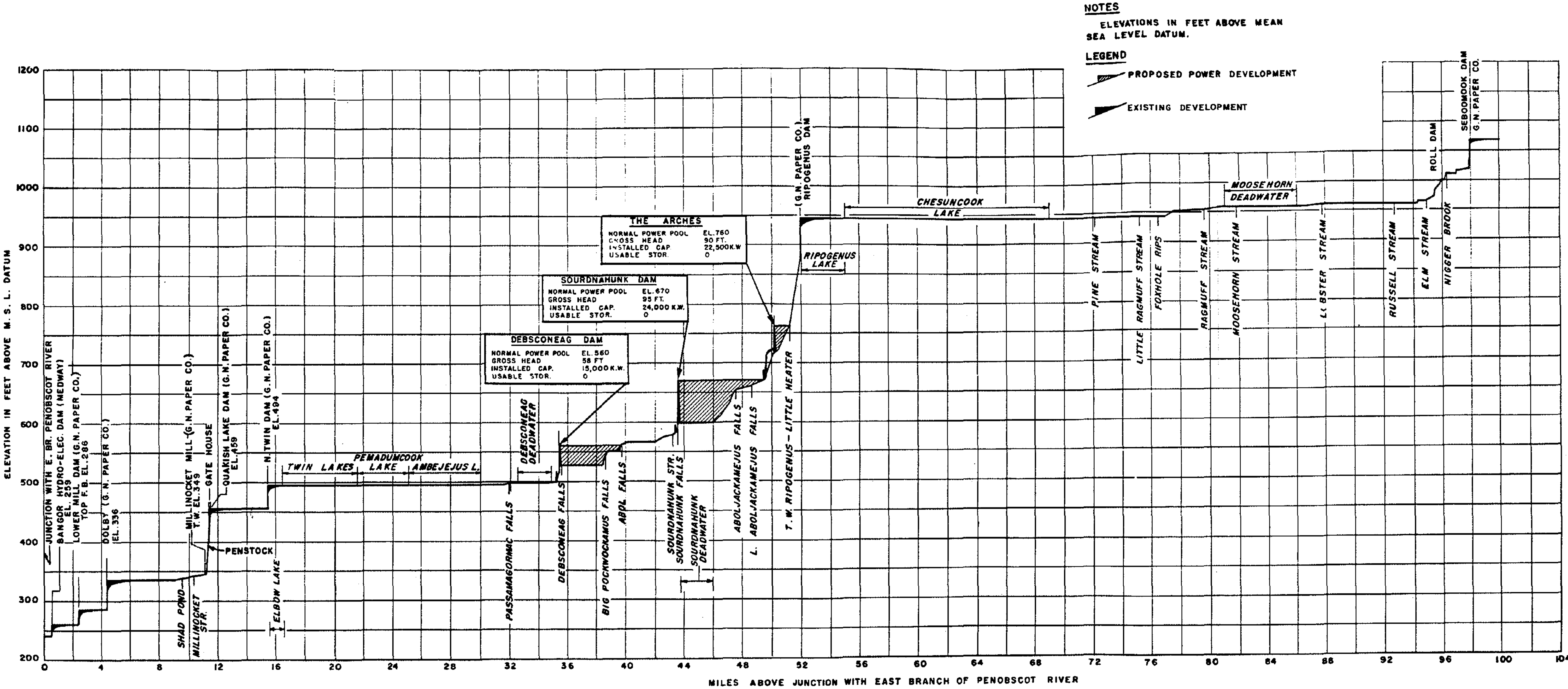
PROFILE

NEW ENGLAND-NEW YORK INTER-AGENCY COMMITTEE

DECEMBER 1952

SCALES AS SHOWN

NOTE: PROPOSED NENYIAC PROJECTS HAVE NOT BEEN DEVELOPED.

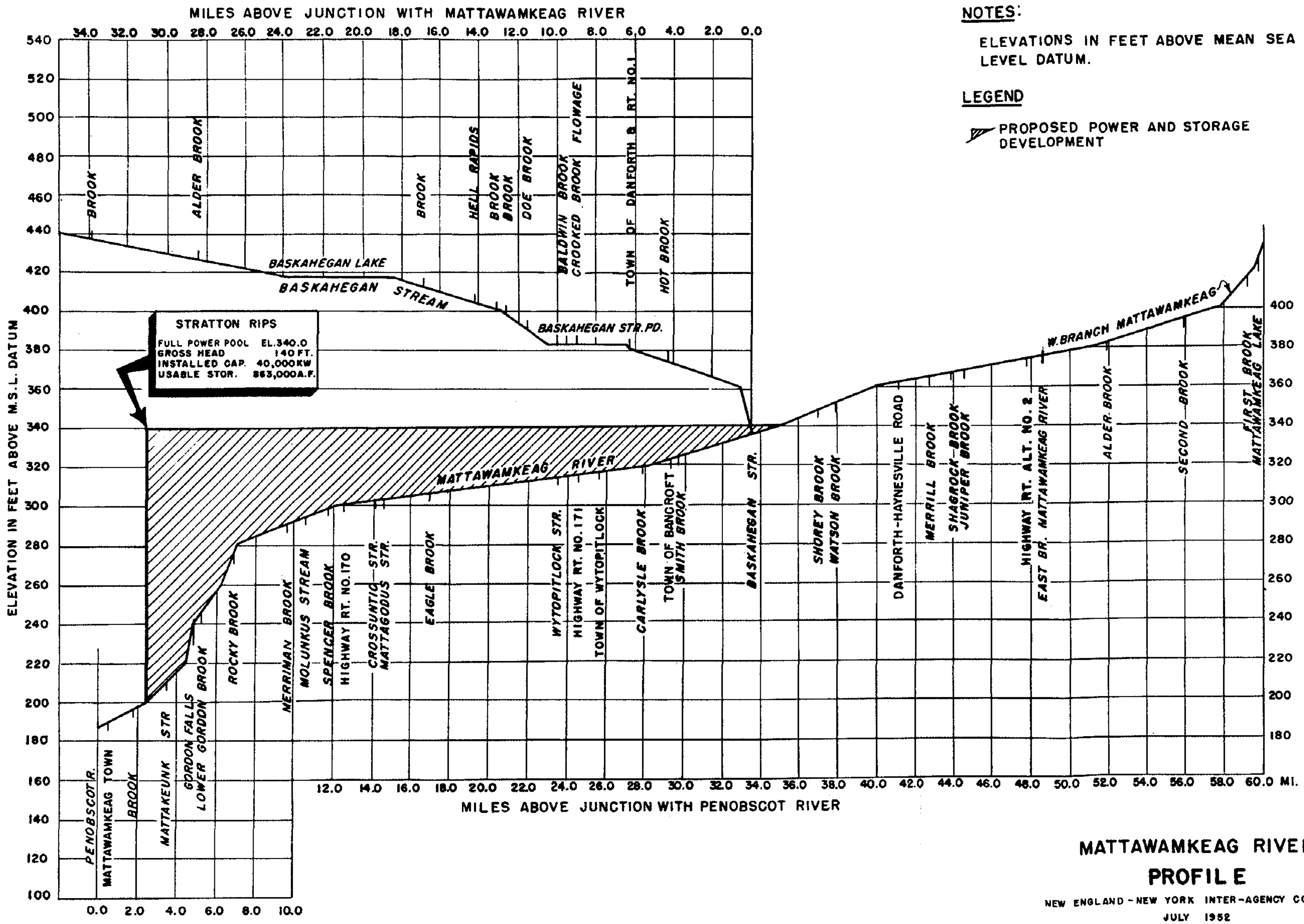


NOTE: PROPOSED NENYIAC PROJECTS HAVE NOT BEEN DEVELOPED.

WEST BRANCH PENOBSCOT RIVER
PROFILE

NEW ENGLAND - NEW YORK INTER-AGENCY COMMITTEE
AUGUST 1952
SCALES AS SHOWN

PLATE 7C



NOTES:

ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL DATUM.

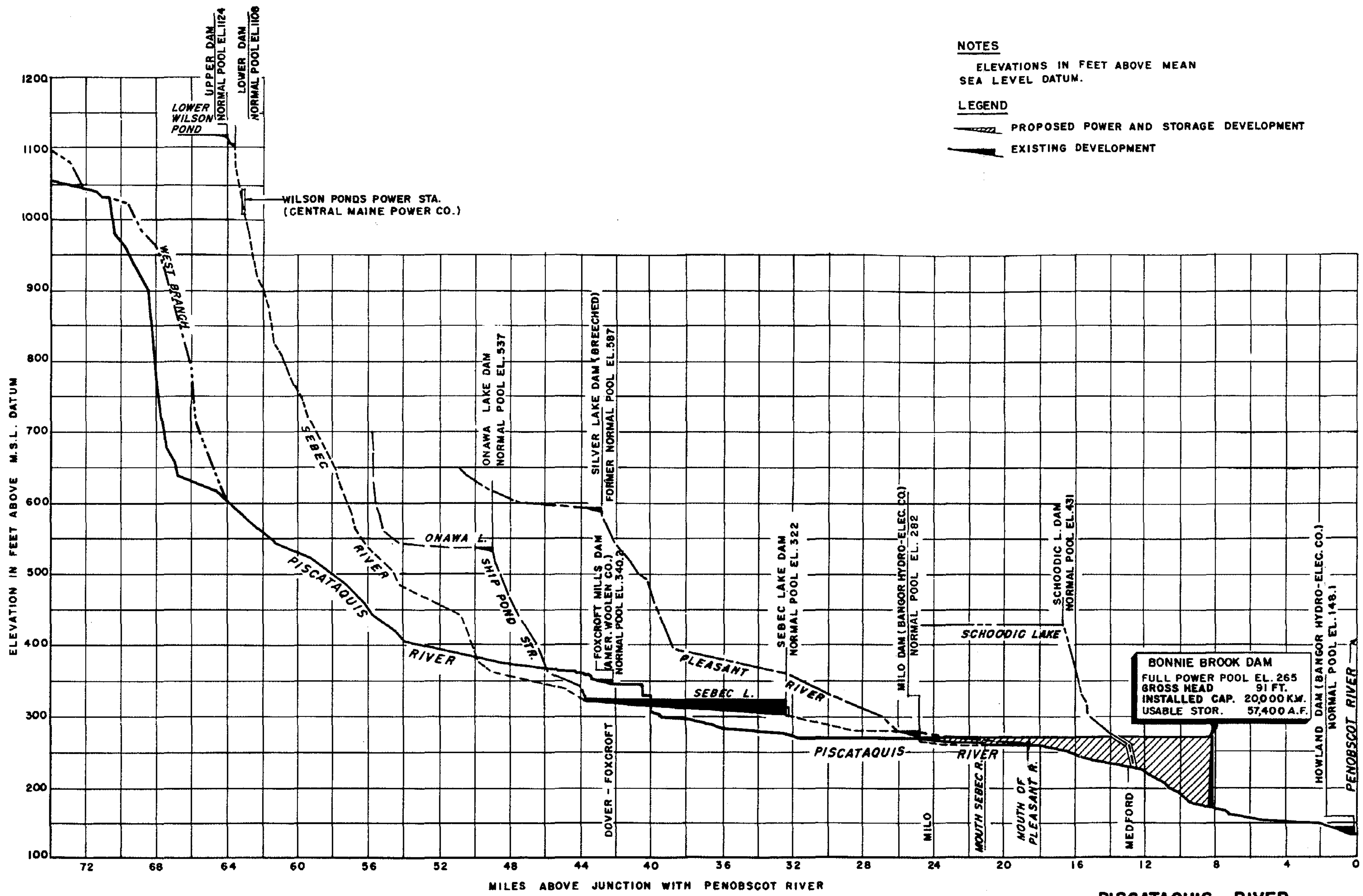
LEGEND

PROPOSED POWER AND STORAGE DEVELOPMENT

MATTAWAMKEAG RIVER
PROFILE

NEW ENGLAND - NEW YORK INTER-AGENCY COMMITTEE
JULY 1952
SCALES AS SHOWN

NOTE: PROPOSED NENYIAC PROJECTS HAVE NOT BEEN DEVELOPED.



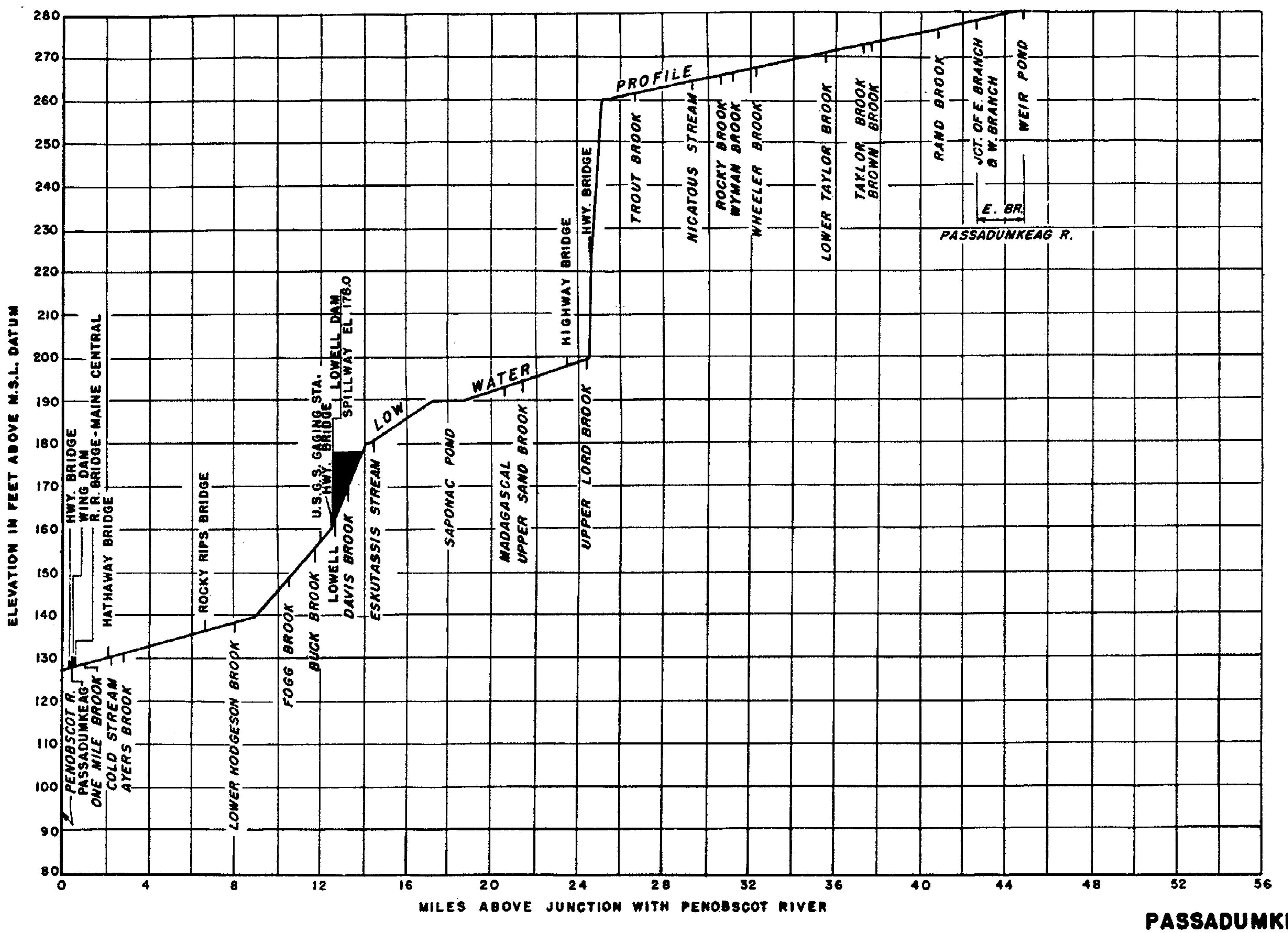
PISCATAQUIS RIVER PROFILE

NEW ENGLAND - NEW YORK INTER-AGENCY COMMITTEE
AUGUST 1952
SCALES AS SHOWN

NOTE: PROPOSED NENYIAC PROJECTS HAVE NOT BEEN DEVELOPED.

NOTES:
ELEVATION IN FEET ABOVE MEAN SEA LEVEL DATUM.

LEGEND:
EXISTING DEVELOPMENT



NOTE: PROPOSED NENYIAC PROJECTS HAVE NOT BEEN DEVELOPED.

PASSADUMKEAG RIVER PROFILE

NEW ENGLAND - NEW YORK INTER-AGENCY COMMITTEE
AUGUST 1952
SCALES AS SHOWN

Appendix B

Economic Analysis

PENOBSCOT RIVER BASIN

RECONNAISSANCE STUDY

ECONOMIC ANALYSIS

APPENDIX B

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Introduction

The purpose of the economics section is threefold. The first is the specification of the flood loss potential as relates to the existing without project condition in the Penobscot River Basin. This will be accomplished by delineating significant flood damage centers, identifying floodplain activities and estimating recurring losses and expected annual losses. Secondly, inundation reduction benefits will be estimated for structural and nonstructural improvement plans. Thirdly, each plan's measure of economic justification will be determined through calculation of a benefit/cost ratio. Net benefits for each plan will also be presented. The economic analysis is performed at the reconnaissance level of detail. Annual losses and benefits reflect the January 1989 level of prices. The applicable interest rate for use in evaluating Federal water resources improvement projects for fiscal year 1989 is 8 7/8%.

Overall Study Area

Based on the problem identification efforts of the project manager and project team and close coordination with State of Maine officials, the following 14 areas were identified as having the most significant existing flood loss potential and required focused study: Abbot, Bangor, Bradley, Brewer, Costigan, Dover/Foxcroft, Eddington, Guilford, Howland, Milford, Milo, Old Town, Orono and Passadumkeag.

Flood Damage Survey

A flood damage survey was performed in the 14 areas by a flood damage evaluator from the New England Division during September to November 1988. Flood related losses were estimated for each floodprone structure and site beginning at the elevation at which discernable losses and damages are first incurred up to the flood elevation of a rare and infrequent (500 year) event. The reference point at each structure was the first floor elevation. In addition to the NED flood damage survey effort, a local architect-engineer firm was contracted with to perform a nonstructural investigation for the 14 areas. As part of the contract, ground and first floor elevations were obtained for all structures in the 100-year floodplain. These elevations added confidence to the estimates of annual losses and benefits. The NED damage evaluator conducted interviews with knowledgeable local people concerning flood losses to commercial, industrial and public activities. For residential properties, use of sampling, typical loss profiles by type of house and minimal interviewing were employed. Both physical and non-physical losses were estimated. The cost of emergency services were obtained where possible. Damages to transportation, communication and utility systems were also obtained from the towns, the State of Maine Department of Transportation and pertinent electric utility companies.

Recurring Losses

Recurring losses are those potential flood related losses which are expected to occur at various stages of flooding under present day development conditions. As the final output of the flood damage survey process, recurring losses are expressed as an array of dollar losses, in one foot increments, from the start of damage to the elevation of a rare and infrequent (500 year) event. Total recurring losses for selected events in the damage centers of the cities and towns under investigation are displayed in Table 1.

TABLE 1
RECURRING LOSSES

Damage Center	Recurring Losses for Selected Events: 10 Year	50 Year	100 Year	500 Year
Abbot	$ 0	$ 4,200	$ 6,900	$ 29,000
Bangor	35,200	176,900	345,000	1,186,500
Bradley	86,400	410,100	768,800	1,579,200
Brewer	30,800	174,600	461,500	1,138,200
Costigan	133,500	852,200	1,571,600	3,015,800
Dover/Foxcroft	1,800	140,200	393,900	1,061,100
Eddington	200	13,000	5,900	104,500
Guilford	93,900	859,500	1,560,500	3,483,100
Howland	193,000	364,000	608,100	2,366,300
Milford	77,700	196,300	377,100	1,329,500
Milo	45,200	719,400	1,350,900	2,211,100
Old Town	316,500	958,300	1,350,500	2,126,900
Orono	27,700	119,900	265,000	873,100
Passadumkeag	64,700	315,100	674,200	1,720,000
TOTAL	$1,106,600	$5,304,000	$9,749,900	$22,224,300

Annual Losses

The purpose of estimating annual losses is to measure the severity of potential flooding on an "expected annual" basis in each damage center. Annual losses are the integration and summation of two sets of data at each damage location. Recurring losses for each flood elevation (event) are multiplied by the annual percent chance of occurrence that each specific flood elevation (event) will be reached. The effectiveness of each alternative flood reduction plane is measured by the extent to which it reduces annual losses. Annual losses in the damage centers of the 14 cities and towns are displayed in Table 2.

TABLE 2
ANNUAL LOSSES

Damage Center	Annual Losses
Abbot	$ 300
Bangor	20,900
Bradley	67,700
Brewer	27,000
Costigan	75,400
Dover/Foxcroft	12,600
Eddington	1,200
Guilford	65,900
Howland	96,700
Milford	33,900
Milo	50,500
Old Town	114,400
Orono	14,500
Passadumkeag	34,300
TOTAL	$615,300

Improvement Plans

Both structural and nonstructural plans were formulated to reduce flood related losses in the basin. The structural plans involve: (i) local protection projects consisting of dikes and walls in selected damage centers and (ii) modification of a dam by adding a bottom hinged gate. The nonstructural plans address: (i) raising the first floors of selected structures, (ii) installation of closures to seal the openings in commercial and residential structures and (iii) an automated flood warning system.

Benefit Estimation Methodology

Benefits were estimated for the different types of improvement plans by use of the following methods. Structural plans: Dikes and Walls - Annual losses prevented under existing conditions were calculated up to the specific level of protection (elevation). Also included are annual losses prevented in the lower one-half of the freeboard range (1.5 feet for dikes and 1 foot for walls). Dam Modification/Channel Modification: Benefits are calculated by comparing annual losses under the natural and modified conditions, based on the reduction in flood levels. Nonstructural plans : Raising of First Floors - Annual losses to each structure were compared without the plan (first floor at existing elevation) and with the plan (first floor raised to one foot above the 100 year flood level). Benefits are the difference in total annual losses. Closures - Annual losses were estimated for each building only for those damage categories that closures would prevent. For example, contents and structures were included, but non-physical losses and grounds were not. Benefits were calculated as reduced annual losses up to the level of protection. All closure plans were evaluated at the 100 year level of protection.

Specific Study Areas and Improvement Plans

In the following analysis of the 14 specific study areas, individual damage centers in each town will be examined in terms of floodplain activities, floodplain characteristics, recurring losses and annual losses. Benefits will be estimated for each local plan of improvement, both structural and nonstructural, and a benefit/cost ratio and net benefits will be calculated for each. The 5 areas on the Piscataquis will be examined first moving downstream from Abbot to Howland. Also moving downstream, the 9 areas on the Penobscot will be examined from Passadumkeag to Brewer.

(1) ABBOT, ME

In Abbot only 3 residential structures, located along Guilford Rd., were identified as floodprone. Two of the 3 structures have first floors above the 100 year flood elevation. Low water entry points for 2 of the 3 houses occur just below the 50 year flood event.

	Recurring Losses - By Event				Annual
	10 Year	50 Year	100 Year	500 Year	Losses
Abbot	$ 0	$ 4,200	$ 6,900	$ 29,000	$ 300

Structural plans were not formulated due to the dispersed locations of the properties and the low amount of annual losses. A nonstructural plan consisting of raising the first floor of one house and floodproofing the basement of another was evaluated.

Nonstructural Improvement Plan - Abbot

Annual Benefits	$ 200
Annual Cost	4,300
Benefit/Cost Ratio	.05 to 1
Net Benefits	$ -

(2) GUILFORD, ME

The existing flood loss potential in Guilford is based on a mix of residential (47), commercial (17) and industrial (5) structures. Damages begin to reach the significant level at the 50 year flood event and increase steadily with the rarer events.

	Recurring Losses - By Event				Annual
	10 Year	50 Year	100 Year	500 Year	Losses
Guilford	$93,900	$859,500	$1,560,500	$3,483,400	$65,900

The only structural plan of improvement is to modify the existing Guilford Dam by adding a bottom hinged gate. This plan will reduce flood stages for 24 properties upstream of the dam and 12 properties downstream. At the 100 year flood event, the plan would reduce recurring losses to the 36 properties by $307,000 or 86%. However, since the plan only affects one-half of total floodprone properties in Guilford, annual losses are not significantly affected and annual benefits amount to $18,100.

Structural Improvement Plan - Guilford

	Dam Modification
Annual Benefits	$ 18,100
Annual Costs	127,800
Benefit/Cost Ratio	.14 to 1
Net Benefits	-

Nonstructural improvement plans were formulated for Guilford for areas above and below the Guilford Dam. The plan for above the dam is to raise the first floors of 5 structures and floodproof the basements of 7 others. The plan for below the dam targets raising the first floors of 28 structures and floodproofing the basements of 3 structures and the first floor of 3 others.

Nonstructural Improvement Plans - Guilford

	Above Guilford Dam	Below Guilford Dam
Annual Benefits	$ 6,600	$ 41,900
Annual Costs	22,100	124,200
Benefit/Cost Ratio	.30 to 1	.34 to 1
Net Benefits	--	--

(3) DOVER/FOXCROFT, ME

There are 11 commercial, 8 residential and 2 industrial structures in the Dover/Foxcroft damage center which totals 21 floodprone buildings. Eleven of the buildings are located above the Foxcroft Dam with the remaining 10 located below. One-half of the structures have first floor elevations slightly below the 100 year flood elevation so flood damages become significant at the 50 year and rarer events. Since there is only a 2 foot difference between the 50 and 100 year flood total annual losses for the 21 properties are not great.

	Recurring Losses - By Events				Annual
	10 Year	50 Year	100 Year	500 Year	Losses
Dover/Foxcroft	$1,800	$140,200	$393,900	$1,061,100	$12,600

One structural improvement was formulated for Dover/Foxcroft. An earthen dike along the Piscataquis River at South Street, upstream of the Foxcroft Dam, would protect 11 structures against the 100 year flood event. Annual losses in this area are $7,900 and the dike would prevent 56% of these losses for a benefit of $4,400. The dike is not economically justified. The annual cost is $29,000 and the benefit/cost ratio is .15 to 1. Nonstructural improvement plans for Dover/Foxcroft were formulated for above the Foxcroft Dam (10 first floor raisings) and below the dam (4 first floor raisings and 2 basement floodproofings).

Nonstructural Improvement Plans - Dover/Foxcroft

	Above Foxcroft Dam	Below Foxcroft Dam
Annual Benefits	$ 4,100	$ 3,600
Annual Costs	41,100	16,700
Benefit/Cost Ratio	.10 to 1	.22 to 1
Net Benefits	--	--

(4) MILO, ME

The flood loss potential in Milo is based on flooding from both the Sebec and Piscataquis Rivers. The damage center, which actually is an aggregation of 4 smaller sub-centers, is comprised of 45 structures, over one-half of which are residential (27) and the remainder commercial (14) and public (4). Damages become significant at events approaching the 50 year flood and grow progressively worse at the rarer events.

	Recurring Losses - By Event				Annual
	10 Year	50 Year	100 Year	500 Year	Losses
Milo	$45,200	$719,400	$1,350,900	$2,211,100	$50,500

Due to the dispersed geographic location of the floodprone structures in Milo a comprehensive structural improvement plan could not be formulated. Nonstructural plans consist of (i) raising the first floors of 22 structures and (ii) floodproofing the basements of 8 other buildings.

Nonstructural Improvement Plans - Milo

Annual Benefits	$35,000
Annual Costs	92,400
Benefit/Cost Ratio	.38 to 1
Net Benefits	--

(5) HOWLAND, ME

There are 92 structures that have flood loss potential in Howland. The majority of the structures (74) are located in the area bordered by Main Street and Water Street while the remainder (18) are located across the Piscataquis River on River Road. Of the total 92 structures residential use is the highest (83) with 30 mobile homes and 53 wooden houses. The remaining buildings are commercial (6) and public (3). Most of the structures in Howland have first floor elevation very close, just above or just below the 100 year flood elevation. Recurring losses therefore become significant for the 50 year flood and rarer events. There is only a 1 foot difference in elevation between the 50 year and 100 year floods.

	Recurring Losses - By Event				Annual
	10 Year	50 Year	100 Year	500 Year	Losses
Howland	$193,000	$364,000	$608,100	$2,366,300	$96,700

The structural plan of improvement for Howland is an earthen dike which provides 100 year flood protection to the area consisting of Water Street, Main Street, Valley Avenue, York Street and Davis Street. The dike will protect 74 structures.

Structural Improvement Plan - Howland

	Dike - 100 year prot.
Annual Benefits	$ 84,400
Annual Costs	99,000
Benefit/Cost Ratio	.85 to 1
Net Benefits	-

Nonstructural plans for Howland include (i) raising the first floors of 33 structures and (ii) floodproofing the basements of 15 other buildings.

Nonstructural Improvement Plans - Howland

Annual Benefits	$57,500
Annual Costs	138,800
Benefit/Cost Ratio	.41 to 1
Net Benefits	--

(6) PASSADUMKEAG, ME

Of the total 42 structures with flood damage potential in Passadumkeag, one-half are located near the confluence of the Passadumkeag and Penobscot Rivers and the other one-half are strung out along Route 2 adjacent to the Penobscot just upstream of the confluence. The structures are nearly all residential (38) with the remainder being commercial (2) and public (2). Only 9 of the structures have first floor elevations below the 100 year flood elevation. The remainder have elevations at or 1 to 2 feet above the 100 year flood. Flood losses approach significant amounts at the 50 year flood and beyond due to many low water entry points at that level.

	Recurring Losses - By Event				Annual
	10 Year	50 Year	100 Year	500 Year	Losses
Passadumkeag	$64,700	$315,100	$674,200	$1,720,000	$34,300

Structural improvement plans were not formulated for this area because the relatively low level of annual losses and the dispersed locations of the properties make economic justification highly doubtful. Nonstructural plans include (i) the raising of the first floor of 19 structures and (ii) floodproofing the basemens of 5 other buildings.

Nonstructural Improvement Plans - Passadumkeag

Annual Benefits	$ 13,300
Annual Costs	79,000
Benefit/Cost Ratio	.17 to 1
Net Benefits	--

(7) COSTIGAN, ME

There are 67 structures in the Costigan damage center, 64 of which are residential structures and the remainder are commercial (2) and public (1). Two-thirds of the structures (45) have first floors which range from 1 to 3 feet below the 100 year flood level. For this reason flood losses reach the moderate stage ($2,000 per structure) at the 10 year event and become quite significant at the 50 year flood.

	Recurring Losses - By Event				Annual
	10 Year	50 Year	100 Year	500 Year	Losses
Costigan	$133,500	$852,500	$1,571,600	$3,015,800	$75,400

A structural alternative was not formulated for the Costigan damage center because the amount of annual losses to be prevented ($75,400) could not economically justify the size of structure required based on the way in which the structures are situated in the floodplain. Nonstructural plans formulated for Costigan include (i) raising the first floors of 52 structures and (ii) floodproofing the basements of 8 other structures.

Nonstructural Improvement Plans - Costigan

Annual Benefits	$ 54,100
Annual Costs	213,000
Benefit/Cost Ratio	.25 to 1
Net Benefits	--

(8) MILFORD, ME

There are 52 structures in Milford which exhibit flood damage potential. Fifty of these are residential and 2 are commercial. Forty-four of the residences are mobile or manufactured homes. In Milford, the flood damages are concentrated in 3 damage sub-centers. All of the mobile and manufactured homes are located near the confluence of the Stillwater and Penobscot Rivers. The hydropower dam is located one mile further downstream and 3 wooden houses are located another mile downstream on Sandy Point Road. Damages become significant at the 50 year flood event in Milford because 15 structures have first floor elevations one foot below the 100 year flood level. However, since there are relatively minor flood losses for the more frequent events, below the 50 year flood, expected annual losses for Milford are only $33,900 or $650 per structure.

	Recurring Losses - By Event				Annual
	10 Year	50 Year	100 Year	500 Year	Losses
Milford	$77,700	$196,300	$377,100	$1,329,500	$33,900

Structural plans were not formulated for Milford because the low level of annual losses to be prevented could not justify the cost of flood control structures in the 3 damage sub-centers. Nonstructural plans that were formulated and evaluated include (i) raising the first floors of 28 structures and (ii) floodproofing the basements of 2 other buildings.

Nonstructural Improvement Plans - Milford

Annual Benefits	$ 21,700
Annual Costs	115,600
Benefit/Cost Ratio	.19 to 1
Net Benefits	--

(9) OLD TOWN, ME

There are 2 separate damage centers in Old Town. One is located upstream of the Milford Dam on the southern end of Indian Island. The second is located downstream of the dam and consists of two areas, one is bordered by Center Street, South Main Street and the Penobscot River and the other includes low-lying portions of French Island. There are 23 structures in the Indian Island damage center of which 21 are smaller-type houses and 2 are small commercial buildings. One-half of the 23 structures have first floor elevations at (3) or below (8) the 100 year flood level. Significant damage begins near the 50 year event as there is only a one foot difference between the 50 and 100 year flood stages. In the main part of Old Town, downstream of the dam, the damage center contains 35 structures all of which are residential. Nineteen of these 35 structures have first floor elevations below the 100 year flood level. The range is 1 to 6 feet below the 100 year level which produces significant losses at the 10 year flood level in this damage center.

	Recurring Losses - By Event				Annual
	10 Year	50 Year	100 Year	500 Year	Losses
U/S of Dam	$ 94,700	$250,800	$388,900	$ 741,800	$32,200
D/S of Dam	221,800	707,500	961,600	1,385,100	82,200
TOTAL	$316,500	$958,300	$1,350,500	$2,126,900	$114,400

Structural plans were not formulated for Old Town because the annual losses to be prevented at each damage center would not justify economically the substantial structure required. Nonstructural planning involved the formulation of measures for 3 separate zones in Old Town. These are (i) French Island zone - 11 first floor raisings and 4 basement floodproofings, (ii) Indian Island Zone - 9 first floor raisings and 2 basement floodproofings and (iii) South Water Street Zone - 14 first floor raisings.

Nonstructural Improvement Plans - Old Town

	French Island	Indian Island	South Water St.
Annual Benefits	$18,100	$12,700	$31,500
Annual Costs	46,100	37,400	57,500
Benefit/Cost Ratio	.39 to 1	.34 to 1	.55 to 1
Net Benefits	--	--	--

(10) BRADLEY, ME

There are a total of 49 structures which exhibit existing flood loss potential in Bradley. The majority of the buildings are residences (43) and the remainder are commercial (3) and public (3). There are actually 2 separate damage centers in Bradley. The first is the Elm Street area which contains 7 structures and is located downstream of the confluence of Great Works Stream. The second and larger of the 2 areas is located along Main Street upstream of the confluence of Otter Stream and the Penobscot River and contains 42 buildings. Of the total 49 buildings, 18 have first floor elevations below the 100 year flood level and 13 have first floors even with it. Significant flood damage is evident at the 20 year event and increases progressively into the rarer flooding events.

	Recurring Losses - By Event				Annual
	10 Year	50 Year	100 Year	500 Year	Losses
Bradley	$86,400	$410,100	$768,800	$1,579,200	$67,700

A structural plan of protection was formulated for the Main Street damage center in Bradley. The plan consists of an earthen dike providing protection against the 100 year flood event. It would be a U-shaped structure located along the Penobscot River, Otter Stream and their confluence. Forty-one structures would be protected.

Structural Improvement Plan - Bradley	Dike - 100 Year Prot.
Annual Benefits	$ 51,100
Annual Costs	102,600
Benefit/Cost Ratio	.50 to 1
Net Benefits	--

Nonstructional plans consist of (i) raising the first of 30 structures and (ii) floodproofing the basements of 9 other buildings.

Nonstructural Improvement Plans - Bradley

Annual Benefits	$ 50,000
Annual Costs	125,300
Benefit/Cost Ratio	.40 to 1
Net Benefits	--

(11) ORONO, ME

The damage center in Orono consists of 27 structures, of which 19 are residential, 1 is commercial and 7 are industrial buildings in a textile mill complex. Only 5 of the structures have first floor elevations below the 100 year flood level with the first floors of the remaining structures range from 1 to 8 feet above that flood level. Flood losses become significant at the 50 year event which in Orono is only 2 feet below the 100 year event.

		Recurring Losses - By Event			Annual
	10 Year	50 Year	100 Year	500 Year	Losses
Orono	$27,700	$119,900	$265,000	$873,100	$14,500

Because of the low amount of annual losses structural plans of improvement were not formulated as economic justification would be highly doubtful. Nonstructural plans include (i) raising the first floor of 8 structures (ii) floodproofing the basements of 4 buildings and (iii) floodproofing the first floor of another building.

Nonstructural Improvement Plans - Orono	
Annual Benefits	$ 8,000
Annual Costs	35,700
Benefit/Cost Ratio	.22 to 1
Net Benefits	--

(12) EDDINGTON, ME

In Eddington, only 4 structures were identified as having flood loss potential. There are 2 residences on Bradley Road and a convenience store and a sportsman club on North Main Street. One structure has its first floor at the 100 year flood elevation while the others are above.

		Recurring Losses - By Event			Annual
	10 Year	50 Year	100 Year	500 Year	Losses
Eddington	$200	$13,000	$15,900	$104,500	$1,200

Structural plans were not formulated due to the minimal level of average annual losses. A nonstructural plan was formulated for the one structure with the first floor at the 100 year flood elevation because it had a low water entry point in the basement. The annual cost to raise the first floor is $4,100 while the annual benefit is $100, therefore this plan is not economically justified with a benefit/cost ratio of .02 to 1.

(13) BREWER, ME

The entire damage center in Brewer consists of 49 structures, all located on North Main Street adjacent to the Penobscot River. The majority of the structures are residential (44) with the remainder commercial (4) and public (1). Only 6 of the structures have first floors situated below the 100 year flood level while 2 more are at that level. Collectively damages become significant at the 50 year event.

	Recurring Losses - By Event				Annual
	10 Year	50 Year	100 Year	500 Year	Losses
Brewer	$30,800	$174,600	$461,500	$1,138,200	$27,000

No structural plan was formulated for Brewer because of the low level of expected annual losses per structure ($550) and because of the linear dispersal of the structures.

The nonstructural plan for Brewer includes (i) raising the first floor of 8 structures and (ii) floodproofing the basements of 6 other buildings.

Nonstructural Improvement Plans - Brewer

Annual Benefits	$17,000
Annual Costs	34,000
Benefit/Cost Ratio	.50 to 1
Net Benefits	--

(14) BANGOR, ME.

The damage center in Bangor is comprised of 14 commercial buildings in the Central Street and Main Street area. There is a mini- mall, parking garage and 12 other buildings that have from 2 to 9 stories. Twelve of the buildings have low water entry points from 1 to 6 feet below the 100 year flood elevation. Damages become significant at the flood elevation of the 50 year event.

	Recurring Losses - By Event				Annual
	10 Year	50 Year	100 Year	500 Year	Losses
Bangor	$35,200	$176,900	$345,000	$1,186,500	$20,900

A structural plan of improvement was not formulated due to the relatively low level of annual losses and the dispersed geographical locations of the buildings. Since all of the buildings are of masonary construction and most are multi-story, the only nonstructural plan is to floodproof the basements of 10 buildings and the first floor of 1 other.

Nonstructural Improvement Plan - Bangor

Annual Benefits	$ 8,300
Annual Costs	16,200
Benefit/Cost Ratio	.51 to 1
Net Benefits	--

Automated Flood Warning System

Benefits which accrue to an automated flood warning system are based on the relationship between forecast lead time and the associated reduction in damages. The underlying assumption is that upon receipt of the flood warning individuals will take appropriate steps to reduce potential damages. Since this is a reconnaissance level study, an existing relationship, in the form of a curve, between forecast lead time and percent reduction in damages was employed. The relationship from Day et al (1969) was used in the 1984 Passaic River Basin Study, New York and New Jersey, and appears to be appropriate for the purposes of this study. The maximum forecast lead time from Day is 48 hours and the corresponding maximum percent reduction in damages is 35 percent. For the towns in the Penobscot Basin the estimated forecast lead times are: 24 hours - Passadumkeag, Costigan, Milford, Old Town, Bradley, Orono, Eddington, Bangor and Brewer; 18 hours - Howland; 12 hours - Abbot, Guilford, Dover/Foxcroft and Milo. The table below displays the derivation of flood warning benefits to each of the study area towns based on annual losses and forecast lead time from the Day relationship.

Town	Forecast Lead Time	Percent Reduction	Annual Losses	Flood Warning Benefits
Passadumkeag	24	29	$ 34,300	$ 9,900
Costigan	24	29	75,400	21,900
Milford	24	29	33,900	9,800
Old Town	24	29	114,400	33,200
Bradley	24	29	67,700	19,600
Orono	24	29	14,500	4,200
Eddington	24	29	1,200	300
Bangor	24	29	20,900	6,100
Brewer	24	29	27,000	7,800
Howland	18	26	96,700	25,100
Abbot	12	22	300	100
Guilford	12	22	65,900	14,500
Dover/Foxcroft	12	22	12,600	2,800
Milo	12	22	50,500	11,100
TOTAL				$166,400

The economic justification of the Automated Flood Warning System is shown below. Annual costs are based on a project life of 15 years and include $51,000 in annual operation and maintenance costs.

	Flood Warning System
Annual Benefits	$166,400
Annual Costs	$126,400
Benefit/Cost Ratio	1.32 to 1
Net Benefits	$ 40,000

Summary of Economic Analysis

The status of economic justification for all plans evaluated for all the basin cities and towns is exhibited in the table below.

Summary of Economic Justification

	Annual Benefits	Annual Costs	Benefit/Cost Ratio	Net Benefits
Abbot:				
Nonstruct.	$ 200	$ 4,300	.05 to 1	--
Guilford:				
Dam Mod.	18,100	127,800	.14 to 1	--
N/S-Above Dam	6,600	22,100	.30 to 1	--
N/S-Below Dam	41,900	124,200	.34 to 1	--

Summary of Economic Justification (con't)

	Annual Benefits	Annual Costs	Benefit/Cost Ratio	Net Benefits
Dover/Foxcroft:				
Dike	$ 4,400	$ 29,700	.15 to 1	--
N/S-Above Dam	4,100	41,100	.10 to 1	--
N/S-Below Dam	3,600	16,700	.22 to 1	--
Milo:				
Nonstruct.	35,000	92,400	.38 to 1	--
Howland:				
Dike	84,400	99,000	.85 to 1	--
Nonstruct.	57,500	138,800	.41 to 1	--
Passadumkeag:				
Nonstruct.	13,300	79,100	.17 to 1	--
Costigan:				
Nonstruct.	54,100	213,900	.25 to 1	--
Milford:				
Nonstruct.	21,700	115,600	.19 to 1	--
Old Town:				
N/S French Is.	18,100	46,100	.39 to 1	--
N/S Indian Is.	12,700	37,400	.34 to 1	--
N/S South-Water St.	31,500	57,500	.55 to 1	--
Bradley:				
Dike	51,100	102,600	.50 to 1	--
Nonstruct.	50,000	125,300	.40 to 1	--

Summary of Economic Justification (con't)

	Annual Benefits	Annual Costs	Benefit/Cost Ratio	Net Benefits
Orono:				
Nonstruct.	$ 8,000	$ 35,700	.22 to 1	--
Eddington:				
Nonstruct.	100	4,100	.02 to 1	--
Brewer:				
Nonstruct.	17,000	34,000	.50 to 1	--
Bangor:				
Nonstruct.	8,300	16,200	.51 to 1	--
Automated Flood Warning System	168,400	126,400	1.32 to 1	40,000

Appendix C

Environmental Considerations

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A. Environmental Resources

A.1 Physical Setting

A.1.a. General

The Penobscot River Basin (Plate C-1) has a surface area of approximately 8570 square miles (NERBC, 1981). The basin is bounded by the St. John River watershed to the north, the St. Croix River watershed to the east, and the Kennebec River watershed to the west. Principal subdrainages within the Penobscot Basin include the West Branch Penobscot (2,100 sq. mi), the Mattawamkeag (1,520 sq. mi), the Piscataquis (1,500 sq. mi.), the East Branch Penobscot (1,100 sq. mi), and the Passadumkeag (394 sq. mi.) (Cutting, 1979).

The upper Penobscot River basin is characterized by rugged relief, with mountains ranging in elevation to over 5,000 feet. Mt. Katahdin, in the central part of the basin, is the highest peak, with an elevation of 5,287 feet. The valley of the Penobscot main stem is characterized by low relief, with hills rising to 300 to 400 feet. Watershed divides along the perimeter of the valley reach elevations of 600 to 800 feet (NERBC, 1981). There are numerous lakes and reservoirs in the basin, with a total area of approximately 250,000 acres (see NERBC, 1981). The two largest water bodies are the Chesuncook and Pemadumcook Reservoirs located on the West Branch.

The West Branch originates near the Canadian border and flows in a southeasterly direction for more than 100 miles (with a drop in elevation of 800 feet) before joining the East Branch at Medway (Dow, 1939). The East Branch flows easterly and southeasterly through lakes and rapids for approximately 75 miles (with a drop of 700 feet) before its junction with the West Branch. Below Medway, the main stem flows southerly for a distance of about 75 miles (with a drop of 230 feet) before reaching tidal waters at the Bangor Dam, and then 27 miles to Penobscot Bay.

Flow of the Penobscot River and its tributaries has been obstructed by various water storage and hydropower dams since the early 1800's (Dow, 1939; Cutting, 1979). At present there are 17 hydropower dams on the river, including seven on the main stem, six on the West Branch, and two on the Piscataquis (NERBC, 1981). Numerous other dams, some with hydropower potential are present in the basin. Flow of the West Branch is intensely managed by a series of eleven storage and five hydropower dams controlled by the great Northern Paper Company. With the exception of a dam near its headwaters (Grand Lake Matagamon), flow of the East Branch is unregulated. Head waters of the Allagash River of the St. John Basin have been diverted into the East Branch via a chain of man-made lakes (Lakes Allagash, Chamberlain, and Telos).

Some reaches of the Penobscot and Piscataquis Rivers under study have received special recognition by the "Maine Rivers Inventory" (Maine DEC, 1982). The mainstem Penobscot from Veazie Dam to Sandy Point at Penobscot Bay has been designated as a category "A" river. This reach has certain outstanding ecological, anadromous fish, and historical resources of regional or national significance. The entire Piscataquis River from the West Branch to the confluence with the Penobscot has been designated a category "B" river. The river has certain outstanding scenic, ecological, anadromous fish, inland fisheries, recreational, and historical resources of statewide significance.

A.1.b. Geology

The basin is underlain by metamorphic bedrock (principally shale, slate, and schist) and intrusions of resistent igneous material (NERBC, 1981). Surficial features are primarily the result of glacial activity and marine sedimentation (Penobscot River Study Team, 1972). Surficial deposits consist largely of glacial till, stratified drift, and marine sediments. Although till is often exposed at higher elevations, in valleys it is generally buried under deposits of marine clay, gravel, or sands. Eskers occur along the main stem and in many tributary valleys. Lowland areas underlain by marine clay and silty sand are typically poorly drained, and in many instances have developed hydric (wetland) soils.

A.1.c. Climate

The climate of the Penobscot Basin is characterized by long, snowy winters, a short spring season, cool summers, and long, mild falls (Penobscot River Study Team, 1972). Normal average daily temperatures in the central part of the basin range from ca. 15 F in February to 65 F in July and August (ESSA, 1968). Temperature extremes are more pronounced inland, than along the coast, where the climate is moderated by the ocean. Annual precipitation in the Penobscot River basin ranges from about 40 inches in the northern part of the basin to 46 inches near the coast (ESSA, 1968). Annual snowfall throughout the basin varies from about 60 inches near the coast to in excess of 100 inches near the headwaters of the East and West Branches.

A.1.d. Water Quality

Historically, water quality of the lower reaches of the Penobscot River was severely degraded by municipal sewage, wastes from paper mills, woolen mills, and tanneries, and other effluents (Dow, 1939). With enactment of the Federal Clean Water Act in 1972, and the subsequent treatment of most major point sources of contamination, river water quality has greatly improved (Maine DEP, 1988).

Current State of Maine Water Quality Classification for stretches of the Penobscot and Piscataquis Rivers under study are presented in Table 1 (state water quality criteria upon which these standards are based are presented in Section F). River water quality at all study sites, except Abbot and Howland, has been designated as class "C". Class "C" waters are suitable for the drinking water supply (after treatment), fishing, recreation (in and on the water), industrial process and cooling water supply, hydroelectric power generation, navigation, and as a habitat for fish and other aquatic life. Waters at Abbot and Howland have been classified as class "B". Class "B" waters are considered suitable for the above mentioned purposes, and retain their full capacity to support aquatic life.

Elsewhere in the Penobscot basin river waters are generally of high

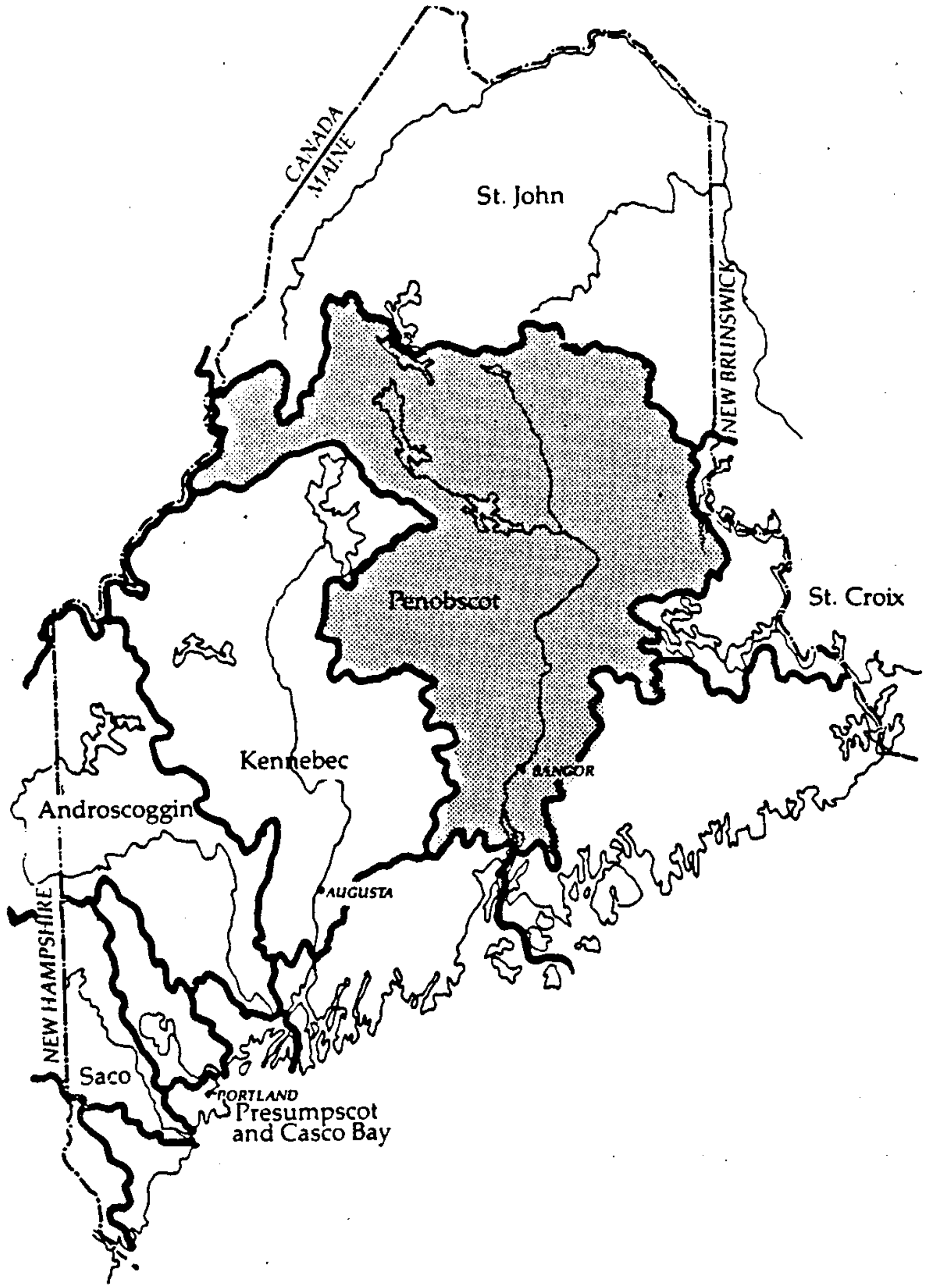

PLATE C-1: The Penobscot River Basin

Table 1. Water Quality Classification in Selected Reaches of the Penobscot River BASIN (adapted from MAINE DEP, 1988)

River	Section	Towns	Classification
Penobscot (main stem)	from the confluence of the East Branch and the West Branch to the Outlet of Reed Brook in the Village of Hampden Highlands	Bradley Brewer Edington Passadumkeag Old Town Orono	C C
Piscataquis	from the confluence of the East and West Branches of the Piscataquis to the Abbot-Guilford Boundary	Abbot	B
	from the Abbot-Guilford Boundary to the confluence with the Pleasant River	Dover-Foxcroft Guilford	C
	from the confluence with the Pleasant River to the dam at Howland	Howland	B
Sebec River	from the dam on Main Street (just down-stream of the project area) to the confluence with the Piscataquis River	Milo	C

quality. Waters in the East and West Branches are typically classified as either Class "A" or "B". Overall, 87 % of the Penobscot (main stem), and nearly 100 % of the East and West Branches are suitable for contact recreation and for the protection and propagation of fish and wildlife resources.

Water quality at several study sites fails to meet water quality objectives (Maine DEP, 1988). The Sebec River in Milo fails to meet Class "C" standards because of high bacterial levels caused by the discharge of untreated residential wastewater. A 34 mile section of the Piscataquis River between Guilford and Medford Center (including the Dover-Foxcroft study area) fails to meet Class "C" bacterial standards. In addition, an eight mile section below Guilford fails to meet Class "C" aquatic life standards because of discharges of untreated municipal and industrial wastewater. Piscataquis water quality below Guilford should improve with the completion of a secondary sewage treatment plant to process both municipal and industrial effluent. A section of the Piscataquis River in Howland fails to meet Class "C" standards for bacteria because of discharges of untreated municipal wastewater. Although water quality standards are not violated, periodic discharges of untreated wastewater and combined sewer overflows can result in elevated bacterial counts in the main stem Penobscot below Veazie. Future water quality will be improved by a number of local treatment plants that are planned or underway.

A.2. Biological Resources

A.2.a Vegetation

Nearly 95 % of the Penobscot River Basin is forested (NERBC, 1981). Major forest types present in the basin are the "spruce-fir" and "northern-hardwoods" associations (see Ferris, 1980). The spruce-fir forest type is dominated by spruce (red, white, or black) and balsam fir. Other tree species commonly present include white cedar, eastern hemlock, eastern white pine, tamarack, red maple, paper birch, aspen, white ash, American beech, sugar maple, and yellow birch. Spruce-fir forests are commonly found in low areas with poorly drained soils, and on thin soils at higher elevations. The northern hardwood type is characterized by American beech, yellow birch, and sugar maple. Other common associated species include basswood, red maple, red oak, white ash, eastern white pine, balsam fir, cherry, paper birch, gray birch, American elm, slippery elm, hophornbean, red and white spruce, and hemlock (Ferris, 1980). The northern hardwood association is typical of areas with deep, moist, well drained soils. Common northern hardwood forest subtypes include aspen-birch, elm-ash-red maple, northern white cedar, grey birch-paper birch, and pin cherry. White pine-oak can be found on sandy, infertile sites.

Little specific published information is available concerning riparian vegetation occurring in the Penobscot River Basin. A list of species noted at study sites along the Piscataquis and main stem Penobscot is presented in Table 2. Frequently occurring trees and shrubs include red maple, red-osier dogwood, alder, box elder, birch (white, gray, and yellow), ash, elm, oak (including red oak), elderberry, and meadowsweet. Frequently

Table 2: Riparian and Aquatic Plant Species Noted at the Study Sites

Common Name	Scientific Name
Trees, Shrubs and Vines	
alder	Alnus rugosa
alder buckthorn	Rhamnus alnifolia
apple	Pyrus malus
ash	Fraxinus sp.
aspen	Populus tremuloides
balsam fir	Abies balsamifera
boxelder	Acer negundo
bigtooth aspen	Populus grandidentata
black cherry	Prunus serotina
black locust	Robinia pseudo-acacia
cedar	Thuja occidentalis
Clematis	Clematis sp.
cottonwood	Populus deltoides
elm	Ulmus sp.
elderberry	Sambucus pubens
green ash	Fraxinus pennsylvanica
grey birch	Betula populifolia
hawthorn	Crataegus sp.
hazelnut	Corylus americana
meadowsweet	Spirea sp.
mulberry	Morus alba
night shade	Solanum dulcamara
oak	Quercus sp.
poison ivy	Rhus radicans
raspberry	Ribes sp.
red maple	Acer rubrum
red oak	Quercus rubra
red-osier dogwood	Cornus stolinifera
silver maple	Acer saccharinum
sugar maple	Acer saccharum
sumac	Rhus typhina
sweetgale	Myrica gale
unidentified Viburnum	Viburnum sp.
white pine	Pinus strobus
white birch	Betula papyrifera
wild rose	Rosa sp.
willow	Salix sp.
yellow birch	Betula lutea

Table 2: continued

Commmon Name	Scientific Name
Grasses and Herbs	
aster	Aster sp.
blue vervain	Verbena hastata
broadleaf cattail	Typha latifolia
bullrush	Scirpus sp.
buttercup	Ranunclus sp.
burdock	Arctium minus
burreed	Sparganium sp.
cinquefoil	Potentilla sp.
climbing hempweed	Mikania scandens
clover	Trifolium sp.
foxtail	Alopecurus
goldenrod	Solidago sp.
Japanese knotweed	Polygonum sp.
milkweed	Asclepias sp.
mint	Mentha sp.
mullein	Verbascum thapsus
purple loosestrife	Lythrum salicaria
reed canary grass	Phalaris arundinacea
rush	Juncus effuscens
sedge	Carex spp.
sensitive fern	Onoclea sensibilis
turk's cap lilly	Lilium superbum
wild carrot	Daucus carota
wild cucumber	Echinocystis sp.

occurring herbs include goldenrod, asters, Japanese knotweed, sensitive fern, and wild cucumber. Reed canary grass occurred at many sites. Because site visits took place in mid November, only a limited inventory of the herbaceous species and grasses present was possible. Site specific information is presented in Section B.

A.2.b. Fish

Anadromous species occurring in the Penobscot Basin include Atlantic salmon, American shad, alewife, blueback herring, striped bass, rainbow smelt, and Atlantic sturgeon. Salmon, shad, and alewife were extraordinarily abundant prior to the construction of obstructing dams and the degradation of water quality by industrial discharges (Cutting, 1979). Runs of adult salmon in the Penobscot numbered between 45,000 and 75,000 before 1800, but were virtually extirpated by the 1950's. Runs of American shad, alewife, and undoubtedly other anadromous species, have also been drastically reduced.

Since the 1960's the State of Maine has been committed to the restoration of the Penobscot's anadromous fisheries resources (Maine DEC, 1982). The construction of functional fishways at dams, improved water quality, and an intensive stocking program has resulted in a resurgence of Atlantic salmon populations. Average runs of about 3,225 adult salmon occurred below the Veazie Dam between 1982 and 1987 (Atlantic Sea Run Salmon Commission, 1988). At present, fish passage facilities provide salmon (and other anadromous species) access to all reaches of the Penobscot and Piscataquis under consideration in this study. Salmon were once abundant in the Piscataquis River system, and smolts and parr have been observed in recent years in the river and its tributaries (Atlantic Sea Run Salmon Commission, 1988). Current plans call for the passive restoration (i.e. with little or no stocking) of shad and alewife fisheries.

Historically, the Penobscot supported important commercial salmon and shad fisheries. At present, the river reportedly offers the nation's largest recreational Atlantic salmon fishery. Pools at the Bangor and Veazie Dams are probably the most productive and intensively fished waters for salmon in the Eastern United States. The mainstem Penobscot also supports a popular rainbow smelt fishery. The Orland River, a tributary on the lower Penobscot near Bucksport, supports an important alewife fishery.

Warm water fisheries are found at all study sites, and are comprised primarily of smallmouth bass (an introduced species), chain pickerel and yellow and white perch. Other fish species expected to commonly occur in reaches under study include red-breasted sunfish, longnose and white sucker, fallfish, blacknose dace, creek chub, common shiner, brown bullhead, American eel, and sea lamprey.

The Piscataquis River provides a quality recreational brook trout and smallmouth bass fishery, and offers good access for anglers. Brook trout are currently stocked in the Piscataquis by the Maine Department of Inland Fish and Wildlife. Annual plants occur in the Guilford to Dover-Foxcroft reach.

A.2.c. Birds.

A list of species likely to occur in riparian habitats in the Penobscot River Basin is presented in Table 3. Birds noted during November, 1988 site visits include great blue heron, mallard, common merganser, double-crested cormorant, herring gull, belted kingfisher, American crow, black capped chickadee, American robin, song sparrow, and winter wren.

A.2.d. Mammals

A list of mammals likely to occur in the Penobscot River Basin is presented in Table 4. Common species that could be expected to occur in riparian habitats include beaver, muskrat, mink, snowshoe hare, raccoon, striped skunk, porcupine, eastern chimpmunk, woodchuck, mice, shrews, voles, grey and red squirrel, red fox, and white tailed deer. Evidence of beaver was noted at many study sites.

A.2.e. Threatened, Rare, and Endangered Species

The Penobscot Basin provides both nesting and overwintering habitat for the bald eagle, a federally listed species (see August 22, 1988 and January 30, 1989 letters from Gordon Beckett, U.S. F.W.S.). Several nesting sites exist along the mainstem Penobscot and its tributaries. Nesting birds are known to forage along the lower Passadumkeag River, and roost on islands near the river mouth. The river from Bucksport to Veazie dam is regarded as one of the most important areas for wintering bald eagles in the state (Maine DEC, 1982). Overwintering birds tend to concentrate around open water areas, particularly below dams, and have been observed in the vicinity of the Howland and Great Works dams during December through March.

The shortnose sturgeon, an endangered anadromous fish, is known to occur in the Penobscot River estuary (Dadswell et al., 1984).

A number of endangered, threatened, or rare plants may occur in riparian habitats along the Penobscot and Piscataquis rivers. Extant and historic records for species occuring at or near study sites are summarized in Table 5 (see also March 20, 1989 letter from Francie Tolan, Maine Natural Heritage Program). Shining Ladies'-tresses (Spiranthes lucida) a threatened species in Maine, and a rare sedge (Carex hassei) are reported from the Dover-Foxcroft study site. Lampsilis cariosa is reported to occur at the Passadumkeag study site.

Table 3: Birds Likely to Occur in Riparian Habitats of the Penobscot River Basin

Great Blue Heron	White-breasted Nuthatch
Mallard	Brown Creeper
Black Duck	House Wren
Wood Duck	Gray Catbird
Common Merganser	American Robin
Hooded Merganser	Veery
Red-shouldered Hawk	Golden-crowned Kinglet
Broad-winged Hawk	Ruby-crowned Kinglet
Bald Eagle	Cedar Waxwing
Osprey	Starling
Killdeer	Solitary Vireo
Spotted Sandpiper	Red-eyed Vireo
Screech Owl	Yellow Warbler
Belted Kingfisher	Yellow-rumped Warbler
Common Flicker	Black-throated Green Warbler
Pileated Woodpecker	Ovenbird
Yellow-bellied Sapsucker	Northern Waterthrush
Hairy Woodpecker	Common Yellowthroat
Downy Woodpecker	American Redstart
Eastern Kingbird	Red-winged Blackbird
Great-crested Flycatcher	Northern Oriole
Eastern Phoebe	Rusty Blackbird
Tree Swallow	Common Grackle
Bank Swallow	Brown-headed Cowbird
Blue Jay	Northern Cardinal
Black-capped Chickadee	Purple Finch
Tufted Titmouse	American Goldfinch
Northern Junco	White-throated Sparrow
Swamp Sparrow	Song Sparrow

based on general information contained in Brinson et al. (1981), Farrand (1983), and Peterson (1980).

Table 4. Mammals Occuring in the Penobscot River Basin

Insectivors

Masked shrew (Sorex cinerus)
Northern Water shrew (Sorex palustris)
Long-tailed shrew (Sorex fumeus)
Pygmy shrew (Sorex hoyi)
Short-tailed shrew (Blarina brevicauda)
Hairy-tailed mole (Parascalops breweri)
Star-nosed mole (Condylura cristata)

Carnivors

Raccoon (Procyon lotor)
Marten (Martes americana)
Fisher (Martes pennanti)
Shorttail weasel (Mustela erminea)
Longtail weasel (Mustela frenata)
Mink (Mustela vision)
Striped skunk (Mephitis mephitis)
River otter (Lutra canadensis)
Coyote (Canis latrans)
Red fox (Vulpes vulpes)
Bobcat (Felis rufus)
Lynx (Lynx candensis)
Black bear (Ursus americanus)

Hoofed Mammals

White-tailed deer (Odocoileus virginianus)
Moose (Alces alces)

Bats

Little brown myotis (Myotis lucifugus)
Keen myotis (Myotis keenii)
Small-footed myotis (Myotis subulatus)
Eastern pipistrel (Pipistrellus subflavus)
Silver-haired bat (Lasionycteris noctivagans)
Big brown bat (Eptesicus fuscus)
Red bat (Lasiurus borealis)
Hoary bat (Lasiurus cinereus)

Rodents

Woodchuck (Marmota monax)
Eastern chipmunk (Tamias striatus)
Gray squirrel (Sciurus carolinensis)
Red squirrel (Tamiasciurus hudsonicus)
Northern flying squirrel (Glaucomys sabrinus)
Beaver (Castor canadensis)
Deer mouse (Peromyscus maniculatus)
Southern bog lemming (Synaptomys cooperi)
Boreal red-backed vole (Clethrionomys gapperi)
Meadow vole (Microtus pennsylvanicus)
Yellownose vole (Microtus chrotorrhinus)
Muskrat (Ondatra zibethicus)
Meadow jumping mouse (Zapos hudsonicus)
Woodland jumping mouse (Napaeozapus insignis)
Porcupine (Erethizon dorsatum)
Snowshoe hare (Lepus americanus)

a. adapted from general distribution maps provided by Burt and Grossenheider (1952)

Table 5: Occurrence of Rare Plants in the Vicinity of the Project Areas.

Species	Status[a]	Location[b]	Habitat[c] Notes
<u>Extant Records</u>			
Carex hassei	WL	Dover-Foxcroft Study Site	moist calcerous soils
Carex oronensis	E	Penobscot River between Howland and Passadumkeag; Basin Miles (near Orono)	dry or moist soils
Erigeron hyssopofolius	WL	Dover-Foxcroft	rocky shores , banks
Houstonia longifolia		Penobscot River between Howland and Passadumkeag	dry gravelly soils
Lampsilis Cariosa		Passadumkeag Study Site	
Spiranthes lucida	T	Dover-Foxcroft Study Site	damp woods, shores
Viola novae-angliae	SC	Penobscot River near Eddington	gravelly or snady shores, rocky crevices near waterways
<u>Historic Town Records</u>			
Carex adusta	SC	Old Towne	dry soils
Carex oronensis	E	Bangor, Orono	dry or wet soils
Ceanothus americanus	T	Orono	upland woods
Eleocharis pauciflora	E	Guilford	wet calcerous shores
Hieracium robinsonii	PE	Piscataquis from Daggett Brook to Guilford	rocky ledges and shores
Houstonia longifolia		Orono	dry gravelly soils
Mimulus ringens var coleophilus	WL	Bangor	wet forests
Platanthera flava	SC	Dover-Foxcroft	wet soils, floodplains
Primula mistassinica	WL	Dover-Foxcroft	rock cliffs, gravelly shores
Sagittaria montevidensis		Bangor	emergent wetlands, streams
Scutellaria parvula	SC	Dover-Foxcroft	upland forests, rock ledges
Trisetum melicoides	E	Dover-Foxcroft	
Viola novae-angliae	SC	Old Town	gravelly or sandy shores, rocky crevices near waterways

a. E: endangered; T: threatened; SC: special concern; SC-PE:special concern - possibly extirpated; WL: watch list; see "Official List of Maine's Plants That Are Endangered or Threatened", Maine Stare Planning Office, 1988

b. source: March 20, 1989 letter from Francie Tolan and January 30, 1989 letter from Gordon Beckett

c. from Gleason (1952).

B. Site Specific Resources

1. Abbot

Study sites are near the intersection of Back Guilford and Davidson Roads, and along Route 16 south of Abbot. The Back Guilford road location has widely scattered homes among fields and wet meadows. Meadow vegetation is dominated by grasses (reed canary grass, foxtail, and others). Species noted along Brown Brook and the Piscataquis River included alder, yellow birch, white birch, red osier dogwood, elderberry, bigtooth aspen, sugar maple, elm, and white pine. Vegetation at the second location consists of emergent wetlands and scrub-shrub communities dominated by alder.

2. Bangor

The study site is located in downtown Bangor, along the Kenduskeag Stream. The site extends along both sides of the stream from the confluence of the Penobscot to the Fraklin Street Bridge. This reach of the Keneduskeag is channelized and offers little wildlife habitat value. Riparian vegetation is limited to ornamental trees and shrubs planted at the base of floodwalls lining the channel. The stream channel between Franklin and State Streets is bisected by a grassy strip of land maintained as a public park. Areas adjacent to the Keneduskeag channel is developed with buildings, lawns, and parking lots.

3. Bradley

The study site extends 2000 feet downstream along the east bank of the Penobscot from below the Great Works Dam to the confluence with Otter Stream, and 2000 feet upstream along the north bank of Otter Stream to the Bullen Street bridge. A broad, forested wetland occurs along most of Otter Stream. Species noted included box elder, black cherry, cottonwood, oak, red maple, red-osier dogwood, alder, elm, ash, apple, hawthorne, elderberry, wild rose, raspberry, sensitive fern, wild cucumber, aster, goldenrod, reed canary grass, and unidentified grasses. There is a substantial amount of standing and fallen dead wood present to provide habitat for cavity nesting birds and mammals. Dense thickets of hawthorne and apple also offer good food and cover value for wildlife. Part of the riparian zone is mowed, and appears to have been filled to establish a low dike. Emergent vegetation noted growing in the stream included bullrush, rush, broadleaf cattails, grasses, blue vervain, and purple loosestrife. The emergent community was best developed in a broad area just upstream of the Route 128 bridge. Upstream of this area Otter Stream narrows considerably, and supports only scattered emergent vegetation. Mallards were observed feeding among wetland vegetation in the stream. Along the Penobscot, the study site consists primarily of forested wetlands with species composition similar to that along Otter Stream. An old field occurs near the confluence of the Penobscot with Otter Stream.

4. Brewer

The study site extends downstream along the east bank of the Penobscot for 3000 feet, beginning about 2000 feet below the confluence with Eaton

Creek. A narrow band of riparian vegetation exists along the Penobscot River. The remainder of the floodplain consists of cleared areas and lawns. Species noted along the edge of the river include box elder, ash, willow and Japanese knotweed.

5. Dover-Foxcroft

The study site is situated along both banks of the Piscataquis River, upstream of the Dover-Foxcroft dam. Most of the riparian zone on the north side of the river, in the vicinity of Moosehead Furniture, has been developed, and has little habitat value. Existing vegetation along the reach from the dam upstream to an earth and rock berm consists of goldenrod, grasses, nightshade, box elder, red maple and various ruderals (i.e. wild carrot, clover, mullein, milkweed, burdock). Approximately 50 % of the bank along this reach has been riprapped. Vegetation noted growing along the existing berm includes box elder, red maple, elm, goldenrod, and grasses. Shining Ladies'-tresses (Spiranthes lucida) a threatened species in Maine, and a rare sedge (Carex hassei) are reported from the study site by the Maine Natural Heritage Program. The opposite (south) side of the river is largely devoid of riparian vegetation. The embankment along the downstream reach is riprapped and abuts a roadway. A small (ca. 0.5 acre) cattail marsh exists near the upstream limit of the study area. Species noted in or near the marsh included elderberry, wild cucumber, burreed, burdock, esses (Spiranthes lucida) a threatened species in Maine, and a rare sedge (Carex hassei) are reported from the study site by the Maine Natural Heritage Program. The opposite (south) side of the river is largely devoid of riparian vegetation. The embankment along the downstream reach is riprapped and abuts a roadway. A small (ca. 0.5 acre) cattail marsh exists near the upstream limit of the study area. Species noted in or near the marsh included elderberry, wild cucumber, burreed, burdock, urces was conducted.

7. Guilford

There are three study sites in Guilford. One site is located along Elm Street, upstream of the Guilford Dam. A second site is immediately upstream of the dam, in downtown Guilford. The third site is downstream of the dam, and extends along the Piscataquis from River Street to the mouth of Schoolhouse Brook, and 750 feet upstream along the west bank of the brook.

The upstream reach at the Elm Street site consists of a broad, flat riparian zone supporting emergent and scrub-shrub wetland vegetation. The zone is about 1500 feet long and varies in width from about 50 to 250 feet. Species noted included reed canary grass, meadowsweet, goldenrod, Clematis, sedges, alder, raspberry, elderberry, red maple, grey birch, white birch, red-osier dogwood, willow, bigtooth aspen, mulberry, turk's cap lilly, and unidentified grasses. Submerged macrophytes were growing along the river's edge. Evidence of beaver and moose was noted. The riparian zone is bordered by lawn (near a new housing development), and recent mowing appears to be encroaching on the riparian community. The downstream reach was more heavily wooded. Species noted on or near the embankment included ash, birch, white pine, cedar, red maple, and mulberry.

At the second study area, the riparian zone is heavily developed, and offers little habitat value. Riparian vegetation along both sides of riparian zone is bordered by lawn (near a new housing development), and recent mowing appears to be encroaching on the riparian community. The downstream reach was more heavily wooded. Species noted on or near the embankment included ash, birch, white pine, cedar, red maple, and mulberry.

At the second study area, the riparian zone is heavily developed, and offers little habitat value. Riparian vegetation along both sides of hoolhouse Brook. Other species noted include red-osier dogwood, balsam fir, meadowsweet, and reed canary grass.

8. Howland

The study site extends upstream along the Piscataquis River from near the Main Street bridge to Cross Street. A well developed forested wetland exists near the upstream limit of the project area. Species noted include red maple, white pine, white birch, alder, hazel nut, green ash, silver maple, red-osier dogwood, black cherry, wild rose, grey birch, aspen, elderberry, sensitive fern, goldenrod, and reed canary grass. Sign of beaver activity was noted. Downstream, riparian vegetation consists of cattered trees and shrubs near the river's edge. Species noted included white pine, red maple, white birch, black cherry, oak, elm, elderberry, raspberry, cinquefoil, and buttercup. Much of the riparian zone has been developed or is disturbed (i.e. lawns, bare ground). Fill has recently been placed in the river at a trailer park. Scattered stands of emergent vegetation (sedges, reed canary grass, and softrush) also occur along the river. An emergent wetland exists at the upstream end of the project area (near bridge). The opposite bank was vegetated by grasses, herbaceous vegetation and scattered trees and shrubs. Species noted include white pine, box elder, alder, red maple, red-osier dogwood, ash, white birch, yellow birch, and Japanese knotweed.

9. Milford

Because early in the study only nonstructural options were under consideration at this site, no analysis of environmental resources was conducted.

10. Milo

The study site extends upstream from the Milo Dam along the south bank of the Sebec River for about 1500 feet. An emergent/scrub-shrub wetland exists along the upstream reach of the site (upstream of a railroad bridge). Vegetation was predominately grasses, sedges, and rush (Juncus sp.). Other species noted included cattails, goldenrod, climbing hempweed, sedges, reed canary grass, sensitive fern, raspberry, alder, box elder, meadowsweet, willow, and elm. An active beaver lodge was present along the river. The riparian zone was bordered either by road or developed areas (lawns). Downstream (between railroad bridge and dam) the riparian vegetation was limited to a narrow band near the riverbank. Species noted include willow, red-osier dogwood, grey birch, elm, bullrush, alder, box elder, sedges, Japanese knotweed, and raspberry. Emergent vegetation (cattails and sedges) occurred waterward of the riparian vegetation. Buildings were situated within about 30 feet of the river at one location.

11. Old Town

The principal study site is a 3000 foot stretch along the west bank of the Penobscot River between the Route 2 bridge and the Great Works Dam. The Maine Central Railroad line lies directly adjacent to the river along the upstream reach of the study site. The bank is riprapped and vegetation consists of scattered shrubs, small trees, herbaceous plants, and grasses. Species noted include cottonwood, grey birch, green ash, poison ivy, purple loosestrife, blue vervain, alder buckthorn, box elder, cottonwood, black locust, apple, alder, red maple, sugar maple, elm, red-osier dogwood, night shade, knotweed, meadowsweet, mullein, aster, goldenrod, and grasses. Along the downstream reach, railroad tracks are set back somewhat from the river. Riparian vegetation consists of open field vegetated by grasses and forbs and a wooded area dominated by black locust, red maple, green ash, and elm.

A second study site in Old Town is a small (ca. 1 acre) pond on Indian Island. A narrow band of wetland vegetation occurs along the pond margin. Species noted included sweetgale, meadowsweet, broadleaf cattail, sedges, rush, goldenrod, willow, wild cucumber, and mint. The pond supports a warm water fishery for species such as pickerel, and the Penobscot Indian Nation has expressed an interest in developing some type of fish culture project. Waterfowl and herons reportedly utilize the pond.

12. Orono

The study site is along the west bank of the side channel of the Penobscot that flows around Ayers island. The site extends about 1500 feet along South Penobscot and Union Streets. The riverbank along the project area is forested. Species noted include grey birch, ash, willow, elm, oak, silver maple, red maple, sugar maple, red-osier dogwood, a Viburnum, sensitive fern, sedges, nightshade, Japanese knotweed, reed canary grass, purple loosestrife, wild cucumber, and goldenrod. Riparian vegetation is bordered by lawns and, at the downstream extreme of the project area, an old field overgrown with Japanese knotweed. A well developed emergent community is present in the river. Species noted included loosestrife and unidentified grasses and sedges. Beaver sign was noted throughout the site.

13. Passadumkeag

The study site is at the confluence of the Passadumkeag and Penobscot Rivers. The site extends about 2500 feet upstream along the north bank of the Passadumkeag, and 500 feet upstream along the east bank of the Penobscot. Riparian and upland vegetation present near the confluence of the Passadomkeg and Penobscot includes ash, red oak, red maple, elm, white birch, aspen, black willow, alder, sumac, red-osier dogwood, sensitive fern, sedges, goldenrod, rose, wild cucumber, and grasses. Recent beaver damage was noted. Riparian vegetation upstream from the confluence to the railroad bridge consists of a thin band of trees and shrubs growing on the river bank. In most areas along this stretch of the river lawn extends to the riverbank. Homes are about 30 to 50 feet from the bank. Upstream ofthe railroad bridge homes are well removed from the river. A low area along this reach supports a red-osier dogwood thicket and beaver lodge. The rare plant Lampsilis cariosa is reported to occur at the Passadumkeag study site by the Maine Natural Heritage Program.

II. Environmental Impacts of Potential Projects

In most locations only nonstructural flood control measures (i.e floodproofing or flood warning/evacuation plans) warranted further study. Nonstructural measures generally would entail essentially no impacts to riparian/aquatic habitat or fish and wildlife resources.

Potential structural solutions (dikes or walls) were, however, considered at a number of study sites. A generalized discussion of the environmental effects of dikes and walls is presented below, followed by an analysis of site specific impacts.

A. General Impacts of Dikes and Walls

The primary adverse impacts of dike or floodwall construction include: 1) short-term construction related impacts to habitat, wildlife resources, and water quality, 2) the permanent loss or degradation of aquatic and/or terrestrial habitat and fish and wildlife resources, 3) long-term socio-economic impacts resulting from loss of waterfront access to boaters and fisherman, and possible aesthetic impacts. Each of these impacts is discussed in more detail below.

1. Short-term Construction Related Impacts.

Construction activities would temporarily disturb or displace wildlife occurring near the project area. Some mortality due to nest abandonment or dispersal-related losses (i.e losses due to predation, competition, and road kill) might occur. Mortality associated with nest failure could be reduced by scheduling construction activities during the late summer and fall months. Some habitat might be temporarily degraded by construction activities (i.e. areas used for access roads and directly adjacent to the dike/wall footprint). Although these areas would be expected to recover eventually, habitat value might be reduced for a prolonged period after completion of the project.

Construction activities would disturb fish in the vicinity of the work area. Some would be exposed to elevated suspended sediments levels for short periods of time. Because adult fish are generally tolerant of short-term exposure to high suspended sediment levels (Stern and Stickle, 1978), little or no direct mortality is likely. Fish eggs and larvae, however, might be destroyed by fill material or siltation. Impacts to eggs and larvae would be minimized by placing seasonal restrictions on construction activities, and by employing proper erosion/sediment control techniques to reduce siltation.

2. Long-term Impacts on Biological Resources.

Construction of dikes and walls results in the long-term loss of riparian habitat destroyed by the footprint of the structure. Less tangible impacts to areas landside of protection that become isolated from the river would also occur. Walls displace less habitat than dikes, and are especially desirable in situations where spatial limitations would require the siting of dikes in wetland or aquatic habitat. An incremental cost analysis comparing walls versus dikes would be required to determine the best alternative from an economic as well as environmental standpoint.

The riparian zone provides highly valued wildlife habitat (Thomas et al., 1978; Brinson et al., 1981). Destruction of riparian vegetation and removal of snags would eliminate nesting sites, cover, and food resources used by many species of birds, mammals, and other wildlife. Although dikes may be revegetated with grasses and forbs, Corps of Engineers policies generally preclude the revegetation of dikes with trees or shrubs. Absence of woody vegetation would permanently reduce wildlife abundance and diversity in affected reaches. In urban or rural areas with limited forest cover, riparian zones may provide important habitat and migration corridors for wildlife populations. In addition to loss of habitat, the presence of dikes and/or walls may restrict access to bank habitat for some animals.

Construction of walls and dikes could also adversely impact aquatic invertebrate and fish communities. The placement of fill material may eliminate cover and rearing habitat for fish provided by roots, snags, overhanging banks, and emergent vegetation. Elimination of shade provided by trees can increase water temperatures in smaller streams, and have an adverse effect on cold water fisheries (i.e brook trout and salmon). Removal of trees from the riparian zone would reduce input of leaf litter into streams. Leaf litter is an important food resource for many aquatic invertebrates (see Cummins et al., 1989), and reduced litter input could adversely impact aquatic invertebrate communities (especially in small streams). Fish that prey on invertebrates could also be adversely affected.

3. Long-term Socio-economic Impacts

Dikes and walls can block public access to the water for fishing and other activities, and should be designed to minimize this impact.

Structural protection should also be designed to minimize visual impacts, especially along reaches that are relatively undeveloped and/or highly valued for recreation.

B. Site Specific Impacts

1. Dikes and Walls

a. Bradley

Potential Protection: A dike along a 3000 foot reach of the Penobscot and Otter Stream.

Impacts: Along most of Otter Stream there appears to be ample room to avoid entirely or minimize impacts to existing riparian or emergent vegetation. Some wetlands would be impacted by a dike upstream, near the Bullen Street bridge where homes are close to the stream. Protection alongthe Penobscot would impact a high quality riparian forest.

b. Dover-Foxcroft

Potential Protection: A dike and floodwall along about 1200 feet of the north bank of the Piscataquis River.

Impacts: Because the riparian zone is already heavily developed, loss of wildlife habitat would be minimal, and largely limited to vegetation on existing dikes. Along much of the reach floodwalls are required to minimize or avoid impacting aquatic habitat. Shining Ladies'-tresses (Spiranthes lucida) a threatened species in Maine, and a rare sedge (Carex hassei) are reported from the study site and, if present, could be impacted by dikes or walls.

c. Guilford

Potential Protection: Dikes along a 1500 foot reach of the Piscataquis upstream of the Guilford Dam, and along a reach downstream of the dam from River Street to the mouth of Schoolhouse Brook, and 750 feet upstream along the west bank of the brook.

Impacts: Impacts to riparian habitat along the upstream reach would be minimal since existing wetlands could be avoided by locating a dike entirely on already disturbed areas (i.e. lawn) or on uplands. At the downstream reach, a dike along Schoolhouse Brook would impact a high quality scrub-shrub wetland dominated by alder.

d. Howland:

Potential Protection: Dike along a 3000 foot reach of the Piscataquis extending upstream along the Piscataquis River from near the Main Street bridge to Cross Street.

Impacts: Wetlands exist at both the upstream and downstream limits of the proposed protection. In both areas, however, it appears that wetlands could be avoided by situating protection away from the river. Impacts to riparian vegetation along the middle reach would be minimal since this area is already highly developed. Some emergent vegetation would be lost if the dike footprint were placed in the river.

e. Milo:

Potential Protection: Dike along about 1500 feet of the south bank of the Sebec River upstream from the Milo Dam.

Impacts: Construction of a dike along the upstream reach of the area could impact wetland vegetation. In some locations it appears that wetland impacts could be avoided by situating a dike on lawns or undeveloped uplands. Along the downstream reach, riparian habitat was limited, and impacts would be relatively slight. Along much of this reach it appears that dikes could be built on lawns or uplands.

f. Old Town

Potential Protection: Dike or wall along a 3000 foot stretch of the west bank of the Penobscot River between the Route 2 bridge and the Great Works Dam.

Impacts: Unless the existing railroad yard could be scaled back (i.e. some tracks eliminated) construction of a dike or wall along the upstream reach would destroy some aquatic habitat. Impacts to riparian habitat along this section would be minimal, since existing vegetation is sparse and the embankment has been riprapped. Impacts to higher quality riparian habitat downstream could be minimized by situating a dike away from the river.

g. Orono

Potential Protection: Dike along the west bank of the side channel of the Penobscot that flows around Ayers island. The site extends about 1500 feet along South Penobscot and Union Streets.

Impacts: Along much of the study area construction of a dike would probably impact a narrow band riparian forest situated between residential development and the river.

h. Passadumkeag

Potential Protection: A dike would extend about 2500 feet upstream along the north bank of the Passadumkeag, and 500 feet upstream along the east bank of the Penobscot.

Impacts: It should be possible to completely avoid riparian vegetation along the upstream reach of the Passadumkeag by placing a dike well back from the river. Along the downstream reach of the Passadumkeag, and along the Penobscot, impacts to riparian forest seem probable. The rare plant Lampsilis cariosa is reported to occur at the Passadumkeag study site and could be impacted by dikes or walls.

2. Other Structural Solutions

a. Guilford

Retrofitting of the Guilford dam with a bottom hinge gate to reduce flood stages upstream of the dam is under consideration. Of principle concern would be any impacts this work might have on the effectiveness of the existing fish ladder at the dam. Construction related impacts to water quality and impacts of a cofferdam, if required, would have to be addressed.

b. Old Town

It may be possible to place a flood control gate across the inlet/outlet of the pond on Indian Island in Old Towne. A gate at the mouth of the pond probably would have only minor construction related impacts to wetland vegetation. No long term impacts are anticipated as long as the gate was kept closed only during periods of high water.

C. Coordination with Federal and State Agencies

1. U.S. Fish and Wildlife Service

Mike Tehan of the U.S. Fish and Wildlife Service (FWS), Ecological Services, Concord Field Office, participated in field visits with Corps staff to the study area November 15 - 17, 1988. FWS observations and concerns were outlined in a planning aid letter (Gordon Beckett, dated January 30, 1989) and have been incorporated into this report. Information on Federally listed and proposed threatened or endangered species was also provided in an earlier letter (Gordon Beckett, dated August 22, 1989).

2. U.S. Environmental Protection Agency

Preliminary coordination with Pam Shields of the Region I Wetlands Protection Section (Boston, MA) was initiated. General comments were received in a letter dated March 3, 1989.

3. National Marine Fisheries Service

An informal endangered species consultation was conducted with Tom Bidford (Glouchester, MA) concerning the occurrence of Atlantic sturgeon in the Penobscot.

4. State of Maine

The following individuals were contacted regarding this project:

Steve Timpano, Environmental Coordinator (Department of Inland Fisheries and Wildlife, Augusta)

Paul Johnson, Fisheries Biologist (Department of Inland Fisheries and Wildlife, Greenville)

Patricia DeHond, Botanist (Critical Areas Program, Maine State Planning Office, Augusta).

A letter outlining the occurrence of endangered, threatened and rare plant species in the vicinity of the project areas was recieved from the Natural Heritage Program (Francie Tolan, dated March 20, 1989).

D. Feasibility Study Cost Estimates

Environmental studies in the Feasibility study phase would include preparation of an Environmental Assessment as well as more detailed coordination with Federal, State and local resource agencies. Funds would be allocated to the U.S Fish and Wildlife Service for the preparation of a Fish and Wildlife Coordination Act Report and Endangered Species Consultation.

The cost of required studies would vary according to the complexity of the project, and anticipated impacts. In some cases detailed mitigation plans to compensate for lost wetland habitat would probably be required. The estimated cost to prepare an EA (including FWS funding) for a typical Section 205 project would probably be about $15,000 dollars.

E. References

Atlantic Sea Run Salmon Commission. 1988. Project Performance Report. AFS-24-R-2.

Brinson, M.M., BL. Swift, R.C. Plantico, and J.S. Barclay. 1981. Riparian Ecosystems: Their Ecology and Status. U.S. Fish and Wildlife Service Rep. FWS/OBS-81/17

Burt, W.H. and R.P. Grossenheider. 1952. A Field Guide to the Mammals. Houghton Mifflin Co. (3 rd. ed.).

Cummins, K.W. et al. 1989. Shredders and riparian vegetation. Bioscience. 39: 24-30.

Cutting, R.E. 1979. The Penobscot. In: "Maine Rivers". pp. 40-43. Thorndike Press. Thorndike, Maine.

Dadswell, M.J. et. al. 1984. Synopsiss of Biological Data on Shortnose Sturgeon, Acipenser brevirostrum LeSueur 1818. NOAA Tech. Rep. NMFS 14.

Dow, R.W. 1939. Atlantic Salmon of the Penobscot River. Penobscot River Salmon Committee.

Environmental Data Service, 1968. Weather Atlas of the United States. U.S. Dept. of Commerce pub. reprinted by Gale Research Co. Detroit, Michigan.

Farrand, J. 1983. The Audubon Society Master Guide to Birding (three vol.). Alfred E. Knopf. New York.

Ferris, C. 1980. The Forest System. In: "An Ecological Characterization of Coastal Maine." pp. 9-1 - 9-35. (S.I. Fefer and P.A. Schettig, prin. invest.). U.S. Dept. of Interior. FWS/OBS-80/29.

Gleason, H.A. 1952. The New Britton and Brown Illustrated Flora of the Northeastern United States and Adjacent Canada. Hafner Press. New York

Maine Department of Environmental Protection (Maine DEP). 1982. Maine Rivers Study. (final report).

Maine Department of Environmental Protection (Maine DEP). 1987. Water Classification Program. Bureaus of Water Quality Control. Augusta, Maine.

Maine Department of Environmental Protection (Maine DEP). 1988. State of Maine 1988 Water Quality Assessment. Bureau of Water Quality Control.

New England River Basins Commission (NERBC). 1981. Penobscot River Basin Overview. Boston, Massachusetts.

Penobscot River Study, 1972. Penobscot River Study. Tech. Rep. No. 1. Environ. Studies Cent. Univ. Maine. Orono

Peterson, R.T. 1980. A Field Guide to the Birds East of the Rockies. Houghton Mifflin Co. (fourth ed.).

Stern, E.M., and W.B. Stickle. 1978. Effects of Turbidity and Suspended Material in Aquatic Environments (literature review). U.S. COE (WES) TR D-78-21

Thomas, J.W., C. Maser, J.E. Rodiek. 1979. Riparian zones in managed rangelands-their importance to wildlife. In: Managing Grazing on Riparian Ecosystems to Benefit Wildlife. pp. 21-31. (O.B. Cope ed.). Trout Unlimited, Inc.

U.S. Dept. of Interior. 1975. Penobscot Wild and Scenic River Study.

F. Standards for Classification of Surface Waters (adapted from Maine DEP, 1987).

Class AA waters.

Class AA shall be the highest classification and shall be applied to waters which are outstanding natural resources and which should be preserved because of their ecological, social, scenic or recreational importance.

A. Class AA waters shall be of such quality that they are suitable for the designated uses of drinking water after disinfection, fishing, recreation in and on the water and navigation and as habitat for fish and other aquatic life. The habitat shall be characterized as free flowing and natural.

B. The aquatic life, dissolved oxygen and bacteria content of Class AA waters shall be as naturally occurs.

C. There shall be no direct discharge of pollutants to Class AA waters.

Class A waters.

A. Class A water shall be of such quality that they are suitable for the designated uses of drinking water after disinfection; fishing; recreation in and on the water; industrial process and cooling water supply; hydroelectric power generation except as prohibited under Title 12, section 403; and navigation; and as habitat for fish and other aquatic life. The habitat shall be characterized as natural.

B. The dissolved oxygen content of Class A water shall be not less than 7 parts per million or 75% of saturation, whichever is higher. The aquatic life and bacteria content of Class A waters shall be as naturally occurs.

C. Direct discharges to these water licensed after January 1, 1986, shall be permitted only if, in addition to satisfying all the requirements of this article, the discharged effluent will be equal to or better than the existing water quality of the receiving waters. Prior to issuing a discharge license, the board shall require the applicant to objectively demonstrate to the board's satisfaction that the discharge is necessary and that there are no other reasonable alternatives available. Discharges into waters of this classification which were licensed prior to January 1, 1986, shall be allowed to continue only until practical alternatives exist. There shall be no deposits of any material on the banks of these waters in any manner so that transfer of pollutants into the waters is likely.

Class B waters.

A. Class B waters shall be of such quality that they are suitable for the designated uses of drinking water supply after treatment; fishing; recreation in and on the water; industrial process and cooling water; except as prohibited under Title 12, section 403, and navigation; and as habitat for fish and other aquatic life. The habitat shall be characterized as unimpaired.

B. The dissolved oxygen content of Class B waters shall be not less than 7 parts per million or 75% of saturation, whichever is higher, except that for the period from October 1st to May 14th, in order to ensure spawning and egg incubation of indigenous fish species, the 7-day mean dissolved oxygen concentration shall not be less than 9.5 parts per million and the 1-day minimum shall not be less than 8.0 parts per million in identified fish spawning areas. Between May 15th and September 30th, the number of Escherichia coli bacteria of human origin in these waters may not exceed a geometric mean of 64 per 100 milliliters or an instantaneous level of 427 per 100 milliliters.

C. Discharges to Class B waters shall not cause adverse impact to aquatic life in that the receiving waters shall be of sufficient quality to support all aquatic species indigenous to the receiving water without detrimental changes in the resident biological community

Class C waters.

A. Class C waters shall be of such quality that they are suitable for the designated used of drinking water supply after treatment; fishing; recreation in and on the water; industrial process and cooling water supply; hydroelectric power generation except as prohibited under Title 12, section 403; and navigation; and as a habitat for fish and other aquatic life.

B. The dissolved oxygen content of Class C water shall be not less than 5 parts per million or 60% of saturation, whichever is higher, except that in identified salmon spawning areas where water quality is sufficient to ensure spawning, egg incubation and survival of early life stages, that water quality sufficient for these purposes shall be maintained. Between May 15th and September 30th, the number of Escherichia coli bacteria of human origin in these waters may not exceed a geometric mean of 142 per 100 milliliters or an instantaneous level of 949 per 100 milliliters. The department shall promulgate rules governing the procedure for designation of spawning areas. Those rules shall include provision for periodic review of designated spawning areas and consultation with affected persons prior to designation of a stretch of water as a spawning area.

C. Discharges to Class C waters may cause some changes to aquatic life, provided that the receiving waters shall be of sufficient quality to support all species of fish indigenous to the receiving waters and maintain the structure and function of the resident biological community.

Appendix D

Historic and Archaeological Resources

APPENDIX D

HISTORIC AND ARCHAEOLOGICAL RESOURCES

TABLE OF CONTENTS

This Appendix consists of the following two documents:

APPENDIX D
HISTORIC AND ARCHAEOLOGICAL RESOURCES

HISTORIC PERIOD RESOURCE SUMMARY

The historic development of Penobscot Valley towns occurred largely as a result of the development of the lumber industry during the 19th century. Most communities on the Penobscot River were dependent on the lumber industry which had a dominant position in the local economy. The rise and fall of many of these towns can be tied to the rise and fall of the lumber industry. Several of these towns such as Milford and Oldtown had their economy run by lumber barons who controlled all log booms and water privileges. Other villages like Brewer had several diverse industries, so were better able to develop more independently of lumber manufacturing and its periodic fluctuations. Taken as a whole, the history of the Penobscot Valley towns forms an interesting chapter in Maine history.

ABBOT

The Massachusetts legislature in 1794 granted five townships of land to Bowdoin College to be sold for revenue. One of the areas selected, Number seven, Range seven, became the township of Abbot. The earliest settler, Abraham Moore arrived in 1805 and by 1810 there were 45 people settled in "Moorestown". The area was organized as a plantation around 1817 and was incorporated as the town of Abbot by the Maine legislature in 1827. The town was named for the land agent for Bowdoin College, Professor John Abbot.

The first saw mill in Abbot was built and sold by Abraham Moore sometime before 1816. A grist mill was added by James Gown around 1822. In 1827 Moore built another saw mill which also produced clapboards, in Upper Abbot. Other early industries included a carding and cloth dressing mill which opened in 1842 and a shovel handle factory which relocated to Upper Abbot in 1846. The Crockett Brickyard began operations sometime after 1817 and continued until 1915. Bricks from this yard were used locally, as in the construction of the Guilford Library and were also shipped to Boston.

By 1850 the population of Abbot was 747. This is the highest population figure the town has ever seen. The town was fairly self-sufficient with agriculture the major occupation of the residents. According to the 1850 census, of 236 adult males in Abbot, 193 (82%) were farmers.

The Bangor and Piscataquis Railroad, later to become the European and North American Railroad was chartered in 1861 and opened as far as Guilford. In 1874 an extension was laid to Abbot. This benefited the town's major businesses; J.F. Works lumber yard, O.P. Witham's shingle mill, D.K. Weld's grist mill and George Smith's excelsior factory.

A fire on December 21, 1903 destroyed most of the industries in Abbot Village. The fire originated in the Moosehead Woolen Company and also destroyed the town's saw mill, cider mill, woodworking shop, grist mill, blacksmith shop and machine shop. A second major fire occurred in 1917 which destroyed the excelsior factory. These mills and shops were never rebuilt and major industries never redeveloped in Abbot.

GUILFORD

Township Number 6, Range 7, was one of the five townships granted to Bowdoin College by the Commonwealth of Massachusetts. The first settlers, Robert Low, Jr. and Robert Herring, Jr. arrived in 1806. In 1812 the area became a plantation and was known as Lowstown. The settlement was renamed Fluvanna, but in 1816 when the plantation was incorporated as a town it was changed to Guilford.

The first saw mill in Guilford was built on the Salmon Stream in 1815 by Captain J. Bennett, J. Kelsey and R. Herring, Jr. The water power was insufficient and it went out of business in 1825. A dam was built across the Piscataquis in 1824 in Guilford Village. That same year a saw mill was built and a clapboard machine added. By 1829 there were at least two stores in Guilford Village as well as the saw mill, two clapboard shops, a tannery and a carding and cloth dressing shop. At the same time, a saw mill was built on Davis Pond. It was provided with large supplies of lumber from upriver. The village of North Guilford developed at this location.

From 1827 Guilford steadily grew. In 1831 a grist mill opened in Guilford. A brickyard was in operation at this time and in 1865 the Woolen Factory Company was incorporated. It became known as the Appleyard mill and was located on the site of the present Guilford Industries. In 1864 a company was formed after a small amount of gold was discovered on Lysander Bennett's farm in Guilford. Extensive mining was undertaken, but no rich veins were uncovered, so the enterprise was abandoned.

By 1871 the population was 818. That year the Bangor and Piscataquis Railroad was completed to Guilford. This gave a new impetus to the growth of the town. The Guilford Lumber Company was incorporated in 1893. Lumbering operations continued until 1907 when the company was converted to the Guilford Manufacturing Company.

The two largest industries currently in Guilford are the Hardwood Products Company and Guilford Industries. In 1920 a wooden box mill was acquired and converted into a toothpick factory. This became the Hardwood Products Company, which diversified to produce such items as tongue depressors and ice cream sticks.

The first woolen mill began operation in Guilford in 1865. There were several companies under different owners such as the Piscataquis Woolen Company and the M.L. Hussey Woolen Company which were in operation in 1904. These businesses were consolidated in 1943 and the name changed to Guilford Industries Inc. in 1962. In 1966, Guilford Industries employed more than 500 people and produced over 120,000 yards of fabric weekly.

DOVER-FOXCROFT

The territory of Dover was first surveyed by Samuel Weston in 1791. The first clearing was made by Abel Blood in 1799, but the first permanent settler, Eli Town did not arrive until 1803. The population grew slowly. In 1810 there were 94 people, and by 1820 there were 215. Dover was organized as a plantation in 1812 and was incorporated as a town in 1822.

The town of Foxcroft was one of the townships granted to Bowdoin College in 1795. Colonel Joseph Foxcroft purchased the township in 1800. The first permanent settler, John Spaulding, arrived in 1806. The population was 65 by 1810 and the town was incorporated in 1812. The first saw mill was built by Abel Blood and John Spaulding in 1807. By 1816 the town had its first store, a tannery and a potato whiskey distillery.

The development of the water power at the Dover Great Falls began with the construction of a dam, grist mill and saw mill by Abraham Moore in 1819. A second dam was built in 1821 with a saw and clapboard mill and a hatting business which remained in operation until the dam was washed out in 1830. In 1825 a third dam and canal were completed at the falls and a large grist mill was constructed.

The following year a carding and clothing mill was established and in 1836 this mill was converted into a woolen factory. The mills were destroyed by fire in 1840 with the grist mill being immediately rebuilt. The woolen factory was rebuilt in 1867 and became known as the S.O. Brown and Company. In 1881 the mill was enlarged and in 1899 the property was sold to the American Woolen Company. In 1902 this company employed 225 people. Another woolen factory was established in Dover-Foxcroft in 1846. This became Mayo and Son Incorporated. By 1902 this factory had grown to a complex of 11 buildings and employed over 80 people. Other manufacturers which operated during this period included the Bailey Bros. planing mill, a hoe and fork factory, several lumber mills and a crating box mill.

The James Sullivan Wiley House, a Greek Revival house built in 1849, is within the project area. This house built for Congressman Wiley is listed on the National Register of Historic Places.

MILO

In 1802, Benjamin Sargent and Moses and Stephen Snow began clearing lots for settlement in the township of Milo. The settlement was organized as a plantation around 1820 and was incorporated as a town in 1823. At this time Milo had 97 residents. It was twenty years after the first settlement before a mill was constructed in Milo. In 1823, Captain Winborn A. Sweat built a dam across Trafton's Falls on the Sebec River and established a saw and grist mill. Mr. Thomas White added a fulling mill and carding machine to this privilege in 1829. Joseph Cushing and Company built a woolen factory at this location in 1842 as did James Gifford in 1862.

The town of Milo developed into a commercial center after the opening of the Bangor and Piscataquis Railroad in 1869. The industries that settled in Milo included a shovel handle factory, a clover mill, a wooden bowl factory, hand rake factory, and wood-working mill. The Boston Excelsior Company began production in 1879. The American Thread Company opened a mill in Milo in 1902. This company employed 220 people in the manufacture of wooden spools. Seventy hands were employed at the Milo Textile Company which began operations in 1922.

The construction of the Bangor and Katahdin Iron Works Railroad in 1880 benefited Milo by increasing its accessibility to raw materials and markets. Large quantities of freight were sent through Milo from the Brownville slate quarries and the Katahdin Iron Works.

HOWLAND

Prior to 1820, Major William Hammett of Massachusetts and William Emerson purchased the tract which included the township of Howland. By 1820 some families had already settled in the area.

Agriculture was the chief occupation of the inhabitants and lumbering was the main business of the town. Several saw mills were erected in Howland during the 19th century and logs were driven through the town to booms downriver in Greenbush and Argyle.

PASSADUMKEAG

The first settlers in the township, Enoch and Joshua Ayers, arrived in 1813. The town of Passadumkeag was incorporated in 1834. Passadumkeag developed very slowly since it lacked a good water power to run mills and factories. The town however, was a half-way station for the Old Town to Mattawamkeag stage coach, and Passadumkeag was a good stopping off point for lumber suppliers travelling between Lincoln and Milford.

Around 1864 a company was organized to raft the logs cut on the Passadumkeag Stream. A boom was established on the Passadumkeag just above the village. This was a great convenience to the lumbering operations and benefited the town by increasing business to the hotels and commercial establishments. A steam saw mill was in operation in 1862. However, it was not profitable since it was too costly to transport the lumber to Bangor. This situation changed when the Bangor and Piscataquis Railroad reached Passadumkeag in 1869. The town though prosperous, remained small. In 1880 the population of Passadumkeag was only 302.

MILFORD

In 1796 the Commonwealth of Massachusetts bought from the Indians what became the township of Milford. This area known as Township No. 3, was surveyed in 1801 and the first settler, Joseph Butterfield, arrived in 1803. Before 1820 this area was organized as Sunkhaze Plantation. Between 1820 and 1830 Milford underwent considerable development and emerged as primarily a lumbering town. This was influenced by the purchase of the township by William Bridge and Benjamin Fiske. They began by opening a store and trading with the natives. In 1826, Bridge and Fiske built Milford's first saw mill. A second saw mill and a dam were built on the Penobscot by these entrepreneurs in 1827. By 1835 when the town was incorporated, Fiske and Bridge had constructed eight double mills containing 16 single saws. The center of this business developed as Milford Village.

The lumber business suffered a decline during the "Panic of 1837", a depression which effected the entire country. However, recovery was rapid and by 1840 several new enterprises were being added to the mill complex at Milford. A wooden pail factory, a shingle mill and a clapboard mill all began operation. The Penobscot River Valley became the largest lumber producing area in the country and Bangor became a major lumber-shipping port.

During this time Fiske and Bridge organized the Milford Land and Lumber Company and a monopoly emerged. This company controlled the land, timber, business and commerce on the river. In 1856 the company's holdings included 19,827 acres of land, an interest in a toll bridge, 15 house lots, 14 saws, three lath mills and a grist mill. The Milford Land and Lumber Company continued to control the town's lumber business through the 1880s.

In 1854 a bridge was built across the Penobscot River and the Bangor, Oldtown and Milford Railroad began its run. Milford was the northern terminus for the railroad and the town developed several enterprises for transporting freight up-country from the end of the railroad line.

An economic boom in the lumber industry occurred in Milford in the decades after the Civil War. Milford had over 30 lumber firms in operation in the 1870s and 1880s. In 1878 a fire destroyed most of the mills in Oldtown. The Milford mills were leased by the Milford Land and Lumber Company to the firms which had been using the mills in Oldtown to saw their lumber. In 1878 the railroad was used for the first time to ship the lumber to Bangor. This was much more efficient than the usual way of rafting the lumber down river.

While Milford was mainly a lumber town, during the late 19th and through the 20th century several small and diverse industries did develop. J.L. Spaulding began making hand rolled cigars in 1892 and Ward's Foundry began casting iron in 1899. The J.A. Osgood Snowshoe Factory, situated on the river, remained in operation for about twenty years. In 1917 the John Jordan-Al Wickett Canoe Factory began operations and continued until 1923 when it was destroyed by fire. The St. Regis Paper Company constructed a stud mill at Costigan in 1975.

ORONO

The first settlement in the township of Orono was made by Jeremiah Colburn and Joshua Eayres in 1774. The first saw mill was built at about the same time. The settlement grew very slowly and by 1800 there were only 67 inhabitants. In 1806, Stillwater Plantation as it was known, was incorporated as the town of Orono. The town when incorporated included all of the present towns of Orono and Oldtown. Orono did not experience a large increase in its population until about 1830 during the "Great Land Speculation". Speculation in the woodlands of northern Maine caused property values to rise. Many people moved to the area to buy and sell large tracts of land. Between 1820 and 1830 the population increased from 415 to 1473. The land boom went bust during the depression of 1837. The Bangor and Piscataquis Railroad Company was chartered during this period in 1833. The railroad from Bangor to Orono opened in 1836. In 1840 the town of Orono was divided and Oldtown was incorporated as a separate town.

The lumber business began to develop during the 1830s. Two large dams were built across the Stillwater River near Marsh Island. They were known as the Bennoch and Babcock dams. At one point there were at least 12 mills on the Babcock dam. Another dam was built on the water power at Eayres (Ayers) Falls. By 1850 the following industries were in operation on the Stillwater: seven gangs of saws (each gang being equivalent to three single saws), 52 single saws, one clapboard machine, four barrel manufactories, a grist mill, an oar factory, a sash and blind mill, a stave factory and a batteau (boat) shop.

From 1890 to about 1914 Orono began the transition from a lumber town to a pulp and paper town. The pine that had been the mainstay of the lumber industry was being exhausted. New processes in paper production were being perfected using large quantities of Maine spruce. The Orono Pulp and Paper Company began operations on Eayres Island in 1889. The Bangor Pulp and Paper Company was in operation by 1895 and the Webster Paper Company in 1892. In 1898 Webster Paper became a branch of the International Paper Company. In 1913 the Orono Pulp and Paper Company employed 160 people and the International mill had 100 workers. Both of these mills closed in the 1940s, marking the end of the lumber industry in Orono.

OLDTOWN

The region encompassing the township of Oldtown was once the territory of the Penobscot Indians. Several treaties were made with the English and Colonial governments so that by 1785 the only property still in native hands was Oldtown Island and the 38 islands in the river above Oldtown. In 1790 there were about 100 native families living on the island.

In 1798 a double saw mill was built on the Oldtown Falls. In 1806 a second double mill was built, and a third was constructed in 1824. Samuel Veazie in 1826, purchased half the mills and privileges along the falls. In 1829 he dug a canal and between 1826 and 1833 he improved the water power.

In 1833 sixteen saws and a grist mill were located at the Old Town Falls. In 1852 Veazie gained control of the entire water power after purchasing a block of mills from a Mr. Wadleigh. by 1853 Veazie had 32 saws running on the falls. This entire complex was destroyed by fire in 1878. In 1881 the Oldtown Water-power Company organized to purchase and improve the Veazie property by the construction of a large stone dam, canal and several large mills.

In 1825 a group of lumbermen were granted a charter and constructed the Argyle Boom for stopping and sorting the lumber sent from upriver. General Veazie became sole owner of the boom until 1847 when he sold it to David Pingree and others. During the early years, the boom was a private enterprise run for the benefit of the owners. The lumbermen however were not always happy about the tolls which had to be paid to send their lumber through the boom. In 1854 the Maine legislature formed the Penobscot Lumbering Association. This association was made up of all the lumbermen on the river. They leased the boom from the owners and set their own fees. The Argyle Boom remained in use until around 1930.

There were a large number of saw mills on other water privileges in Oldtown. Several mills were on the Stillwater River at an area called Upper Stillwater. In 1798 General Joseph Treat built a saw mill on the west side of the river. By 1833 a mill with eight saws was in operation on the east side of the Stillwater. In 1833 the Orono Company gained control of this privilege and water power on both sides of the river. This company built a block of mills including the "Washburn Block" which contained six saws. This mill was destroyed by fire in 1863.

Rufus Dwinel bought the privilege at Oldtown Village in 1845.

This water power had a saw mill on it as early as 1817. In 1861 a door, sash and blind factory was added.
Dwinel was also a partner in the mills at Great Works. Dwinel, Sawyer and Company had six mills with twelve saws.

In 1865 a huge fire destroyed a large part of the village. Two churches, two schools, one block of mills with six saws, a door and blind factory, the railroad depot and 22 dwellings were destroyed in the fire. It took the town many years to recover.

BRADLEY

The township of Bradley was purchased from the natives in 1796. The first settlers began to arrive shortly after this date. The first saw mill was built on Great Works Stream sometime before 1814, and was known as Bucks Mills. Around 1820 lumbering operations were started on the Penobscot River so more mills were constructed along the river and streams. Bradley had the advantage of 29 potential privileges on the Great Works Stream, Blackman Stream and the Penobscot River.

In 1833 the Great Works Milling and Manufacturing Company was organized in Bradley. This company constructed a large block of saw mills on the Penobscot at the Great Works privilege opposite the complex of the same name constructed in Oldtown. With the establishment of these mills the village increased in size. Bradley was incorporated as a town in 1835. The town was named after Bradley Blackman, one of the oldest settlers. The chief industry was lumbering. In 1859, the peak for the industry in Bradley, there were 14 single saw mills, three mills with gangs of saws, four clapboard machines, four lath machines and three shingle mills on the water powers.

In 1880 the population of Bradley was 829. The village had developed around the Great Works mills. The Great Works Milling and Manufacturing Company was still in business and operating several large saw mills, a clapboard mill and a shingle mill. The fire at the mills in Oldtown in 1865 had benefited the business at the Bradley mills for several years.

EDDINGTON

The history of Eddington begins with the life of a Revolutionary War hero, Colonel Jonathan Eddy. Colonel Eddy lived in Norton, Massachusetts until 1763 when he relocated to Fort Cumberland, Nova Scotia. During the outbreak of the Revolutionary War, he wished to bring Nova Scotia into the United States. On 12 November 1776 he led an attack on the British stronghold, Fort Cumberland. The raid was unsuccessful and Colonel Eddy had to flee the territory. He then entered the Continental Army. After the war Eddy and 19 of his comrades received, for their services during the Revolution, a grant of 9000 acres of land on the east bank of the Penobscot. Colonel Eddy settled in the area in 1784. Several other families had already settled here sometime around 1780. The township was known as Eddytown Plantation and in 1811 was incorporated as the town of Eddington.

The first saw mill was built at the outlet to Davis Pond sometime around 1800. A grist mill was added by 1803. From 1820 through the 1850s Eddington experienced a period of growth. A mill on Mill Brook in East Eddington manufactured bedsteads from 1825 to 1833. During the 1830s the town also had a large grist mill in operation as well as a saw mill, brick yard and carding mill. By 1840 the population of Eddington had increased to 595.

The lumber industry was also important to this river town. There were several mills which manufactured long and short lumber, shingles, barrel heads and staves, chairs and wooden clothespins. Other industries included an axe factory, oar manufacturer and scythe factory.

In 1879 A.F. Merrill converted his clothespin factory to the manufacture of birch wood spools. This was a major industry in Eddington until the factory was damaged by two fires in 1916 and 1918. The business was then relocated to Brewer which had the benefit of being on the route of the Bangor and Piscataquis so it was easier to ship the merchandise. This company did an extensive business with trade between Bangor and Boston.

By 1918 only one mill remained in Eddington. This saw mill ceased operation in 1919 and in 1935 was converted to a public recreation area.

BREWER

In 1770 John Brewer of Worcester, Massachusetts applied to the General Court of Massachusetts for a grant of territory along the Penobscot River. In 1771 he returned with 21 other settlers, built a saw mill on Segeunkedunk Stream, and founded the village of New Worcester. On 21 March 1788 the General Court incorporated New Worcester Plantation as a town and named it Orrington. By 1790 the population of Brewer was 477. The first grist mill was constructed before 1800 and was wind propelled, and unusual mode of operation in this area.

Settlement in the area was slow but steady. By 1820 there were 1049 people living in Brewer. The town possessed a tannery, two saw mills, two grist mills, three traders, a carding machine and a nail factory. In East Brewer Captain Russell Hart had a lumber mill and later a shingle mill. During the 19th century the manufacture of lumber was a very important industry for Brewer. When lumbering was at its peak there were 17 woodworking mills in operation.

Brewer, unlike other Penobscot River towns which relied solely on lumber, had several major industries throughout the 1800s. The town of Brewer was known as a great shipbuilding town. The first ship built in Brewer was launched in 1800. There were three shipyards in operation before 1850. The industry's major period in the town was after the Civil War. More ships were launched from Brewer, than at Bangor or any other town on the Penobscot River. Between 1849 and 1919, when the last ship was launched from a Brewer shipyard, 163 ships were built. These included bards, schooners, brigs and steamers.

Another major Brewer industry was brick making. Prior to 1850 there were three brick yards in Brewer, with the largest one producing 600,000 bricks a year. During the Civil War the industry slowed down, but the period of 1860-1880 was the most prosperous period for brick manufacturers. In 1860 there were 19 brick yards in Brewer employing 159 people and producing 15,500,000 bricks per year. In 1870 there were 18 yards with 126 employees. There was a great demand for brick throughout New England. Brewer brick was also shipped to North Carolina, Florida, Texas, the West Indies and Newfoundland. By 1910 only four yards remained in operation, and in 1930 only one continued production.

Ice harvesting was once also one of Brewer's major industries. This business reached its peak in the late 1800s with over a dozen companies shipping ice from Brewer. In 1890 506,300 tons were harvested from the Penobscot River. Ice houses were located all along the river throughout the town. The ice had to be packed in sawdust, which was readily available from Brewer's lumber mills. Penobscot River ice was shipped to markets all along the Atlantic seaboard and as far as Cuba.

In 1895 the Eastern Manufacturing Company, New England's largest saw mill, converted one of its factories and began the manufacture of paper in Brewer. The primary business became the production of fine writing paper which began in 1905. In 1942 this company employed over 1200 employees. In 1969 Eastern became a part of the Eddy Paper Company, Ltd. At this time the company employed 460 people and produced over 60,000 tons of fine paper per paper.

BANGOR

The first permanent white settler in Kenduskeag Plantation, Jacob Buswell, arrived in 1769. In 1770, 20 people were living in the area. They settled as sqautters, but were officially deeded, for $5.00, 100 acres of land by the General Court of Massachusetts in 1801. The first trading house was built in 1772 near the mouth of the Kenduskeag Stream by Thomas Goldtwait. Trade was mostly made for fish, furs and lumber.

The first saw mill in Kenduskeag began operations in 1772 and the first grist mill was built 12 years later. The plantation grew very slowly in size during the Revolutionary War. Shipping was cut off by the British who had full control of the river and the plantation was occupied by British troops. New settlers arrived after the war and in 1791 with a population of 169 people, the town of Bangor was incorporated.

The population of Bangor increased slowly for the next 20 years. The Embargo during the War of 1812 led to a depression in the lumber industry. This trade again began to prosper in 1816, and at this time the population had grown to around 1000. One of the first ships built in Bangor, the packet sloop Herald, was constructed around this time. By 1830 the population had increased to 2865 and Bangor was prospering as a market for the lumber trade. The town had few saw mills within its limits but it had the advantage of being the terminus for the lumber which was rafted downriver. The lumber was then shipped to various markets such as Boston and New York. Bangor was incorporated as a city in 1834. The amount of lumber shipped from the port steadily increased from 1832 when 246,453,649 feet of long number passed through Bangor.

In 1880 the population of the city of Bangor and the town of Brewer combined was neraly 20,000. There were 183 sailing vessels or streamers registered at the port of Bangor. The city had numerous industries. These included five shipyards, a boot factory, two grists mills, two foundries, a ladder manufacturer, three planning mills and four tanneries. The ice industry was beginning to assume importance in Bangor. In 1880, 135,000 tons were harvested from the Penobscot River and shipped to New York, Philadelphia, Baltimore and the southern states. In total, the city of Bangor had 285 manufacturing establishments which employed almost 2000 people.

SUMMARY

Any structural alternatives proposed for feasibility studies would require more research into the history and prehistory of the specific project area. This preliminary reconnaissance has revealed that the river's edge and floodplain have been intensively used by prehistoric and historic groups, and much evidence of their activities remain. These would need to be documented before any construction were to take place.

Non-structural alternatives have a lesser potential impact to historic or prehistoric archaeological sites. However, floodproofing of historic structures such as Saint Anne's Church in Oldtown or the James Sullivan Wiley House in Dover-Foxcroft could have an effect on the integrity of these National Register properties. Non-structural solutions, such as floodproofing and raising structures will have to be evaluated for their potential effect on these properties and any other historic structures considered eligible for the National Register of Historic Places. Close inter-agency cooperation will be required to arrive at the best solution for protecting the structures while maintaining their historic integrity.

REFERENCES

Bangor Board of Trade
1883 The City of Bangor in 1883. Bangor.

Beard, Frank A. and Bette A. Smith
1982 Maine's Historic Places. Properties on the National Register of Historic Places. Camden, ME

Bennett, Wayne, Faith Davidson, Alice Hescock Weymouth
1977 Abbot, Maine Sesquicentennial - 1827-1977. [Abbot,ME?]

Day, Clarence Albert
1956 Historical Sketch of Orono: The Orono Sesquicentennial Program Celebrating the 150th Anniversary of the Incorporation of Orono, June 14, 15, 16, 1806-1956. n.p.

Ives, Edward D., ed.
1976 Argyle Boom. Northeast Folklore, Volume XVII.

Loring, Amasa
1880 History of Piscataquis County, Maine From its Earliest Settlement to 1880. Portland, ME.

Lowell, Mary Chandler, comp.
1935 Old Foxcroft, Maine: Traditions and Memories, with Family Records. Concord, NH.

Milford Bicentennial Committee
1976 History of Milford, About its Origin, Growth and its People From 1800. Milford, ME.

n.a.
1882 History of Penobscot County, Maine, with Illustrations and Biographical Sketches. Cleveland, OH.

n.a.
1966 Guilford, Maine Sesquicentennial. Milo, ME.

Norton, David
1881 Sketches of the Town of Old Town, Penobscot County, From its Earliest Settlement, to 1879; with Biographical Sketches. Bangor, ME.

Penobscot River Study Team
1972 Penobscot River Study Technical Report No. 1. Environmental Studies Center, University of Maine at Orono.

Rogers, Hannah W., comp.
1926 A History of Orono, Maine. n.p.

Rube, Burdock
1942 Historical Sketch of East Eddington Area: a Review of the Early Settlement from Meadow Brook to Clifton and the Holden Lines. Bangor, ME.

Smith, Edgar C.
1902 The Early History of Dover and Foxcroft. The Piscataquis Observer, Dover, ME.

Thayer, Mildred N. and Agnes H. Ames
1962 Brewer, Orrington, Holden, Eddington, History and Families. [Brewer, ME?].

U.S. Department of Interior
1987 National Register of Historic Places for the State of Maine

Vickery, James Berry, III
1976 A Pictorial History of Brewer, Maine. Brewer, ME.

West, Rethel
1923 History of Milo, 1802-1923. Dover-Foxcroft, ME.

Wood, Carolyn A.
1976 History of Eddington. For Eddington Bicentennial Committee. n.p.

ABORIGINE CULTURAL RESOURCES IN THE PISCATAQUIS AND CENTRAL PENOBSCOT RIVER DRAINAGE: A MANAGEMENT SUMMARY

by

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ABSTRACT

A summary of the available information about known aboriginal cultural resources in the main stem of Penobscot River and one of its major tributaries, the Piscataquis River, is presented in this report. Over 185 aboriginal cultural resources, consisting solely of archaeological sites, were recorded on the basis of published articles, unpublished reports, and the Maine Site Survey files maintained by the Maine Historic Preservation Commission Although the majority (61%) of the aboriginal archaeological sites are either of unknown prehistoric or unknown general attributions, the sites with diagnostic artifacts and/or radiocarbon dates indicate occupation throughout the entire span of aboriginal occupation, ca. 8300 B.C. to A.D. 1750. Of the total inventory of 97 sites for which erosion information is available, only 14 (14%) are not undergoing any erosion, while 66 (68%) are undergoing moderate, moderate to severe, or severe erosion. Two sites, including one in the recorded inventory in Bradley and another unrecorded in Howland, are specifically located in or adjacent to two of the three areas where structural solutions such as dikes and walls are being investigated by the Corps of Engineers.

INTRODUCTION

The New England Division of the U.S. Army Corps of Engineers contracted with the authors to prepare a summary report of the aboriginal cultural resources located in immediate proximity to portions of the central Penobscot River and the Piscataquis River in Penobscot and Piscataquis counties, Maine. The study area specifically included the portion of the Piscataquis River from Abbot to its confluence with the Penobscot River at Howland and the portion of the Penobscot River from Howland to the head of tide in the area of Bangor and Eddington.

The contractors were requested to compile information on the aboriginal cultural resources within the study area, including the location, condition, and general temporal attribution of each identified resource. In addition, specific information was verbally requested on three areas in Dover-Foxcroft, Howland, and Bradley where the Corps of Engineers is investigating structural alternatives such as dikes and walls to control the flood waters that periodically ravage the study area. This report summarizes this work and provides an initial overview of the relative density and significance of aboriginal cultural resources in this portion of the larger Penobscot River drainage in central Maine.

RESEARCH METHODS

The authors consulted various sources of information to document the aboriginal cultural resources located within the study area. It should be initially noted that all such resources are archaeological sites located immediately adjacent to or in close proximity to the main stems of the Penobscot and Piscataquis rivers within the study area, also including the Stillwater River which is a major channel of the Penobscot River in the area of Oldtown and Orono. The study area did not include the upper or lower portions of the Penobscot River nor any of its other tributaries besides the Piscataquis River. In the case of the Piscataquis, the study area likewise did not include its uppermost headwaters nor any of its tributaries or major lakes, such as Sebec Lake. Thus, the results summarized here only represent a small percentage of the total inventory of aboriginal cultural resources currently identified in the broader Penobscot River drainage. Moreover, it is highly unlikely that all aboriginal cultural resources directly present in the study area are known given the uneven degree of research and consulting archaeology field work undertaken locally to date.

The specific sources of information for this report included a variety of publications which document long term but selective research projects in and near the study area, along with various unpublished reports of research conducted in the study area within the past decade. These written sources are cited in subsequent sections of this report which summarize past research and the known culture history of the study area.

In addition, the Maine Site Survey files as centrally maintained by the Maine Historic Preservation Commission were studied in Augusta. These files potentially include a variety of information about each identified cultural resource, including archaeological sites. However, in actuality they are variably complete in correlation with the specificity of available information at the time they are filed by various research and consulting archaeologists. For example, information about precise topographic settings, soil types, and degree of erosion, among other site characteristics are rarely recorded on the individual site forms. Nonetheless, the site forms provide the only commonly available information for most such resources and thus, have been relied on to provide the basic site summaries included here.

Consultation with several archaeologists and ongoing personal research in the study area also facilitated the preparation of this report. Long term interaction with Dr. David Sanger, William Belcher, and Steven Bicknell at the University of Maine (Orono) provided a broad background for the sites located in the southern portion of the study area. Personal research through grants, consulting contracts, and volunteer efforts through the long term Piscataquis Archaeological Project (PAP) provided a direct knowledge of many of the sites in the Piscataquis River portion of the study area. Numerous local avocational archaeologists, most notably including Mike Brigham, Walter Macdougall, and Tim Russell, also have contributed to the knowledge of sites within the confines of the Piscataquis River drainage. Finally, Dr. Arthur Spiess at the Maine Historic Preservation Commission greatly facilitated preparation of this report through his long term interest in the PAP and access to the Maine Site Survey files and several unpublished reports on file in his office.

The results of this combined information are summarized in Table I. Site designations in the Maine Site Survey are reported for those cultural resources currently known within the study area. General information about site setting, riverine orientation, site type, and degree of erosion, if any, is also included in Table 1.

PAST RESEARCH IN THE STUDY AREA

The systematic study of cultural resources, including archaeological sites, has been variably undertaken in the study area and adjacent portions of the broader Penobscot River drainage over a long period. Although avocational activities in the Penobscot River drainage surely predated 1912 (e.g., Smith 1926), it was the initiation of local work by Warren K. Moorehead in 1912 which marked the beginning of more or less systematic research there. Moorehead's research was concentrated on exploration of cemetery sites of the 'Red Paint People', known to modern archaeologists as the Moorehead complex/phase of the Late Archaic period. Moorehead's work also included general site survey work by necessity in his search for ancient aboriginal cemeteries. His only synthesis of this and other research was published a decade after his initiation of work in Maine (Moorehead 1922), but his work apparently also continued thereafter.

A total of 15 sites are noted on Moorehead's maps of the study area, including 12 sites between the Bangor-Brewer area and Howland at the mouth of the Piscataquis River and 3 sites on the Piscataquis River proper above Howland (Moorehead 1922 Plan maps XV and XVII). Unfortunately, Moorehead only briefly reported his survey work in the study area, with detailed discussion only presented for W.B. Smith's work at the Eddington Bend site (74-8 in the Maine Site Survey files) and his own work at the Godfrey cemetery in Old Town (74-3) (Moorehead 1922:50, 93-94, 115, 120-121,134-143, 219-223).

Of particular note, Moorehead reported a substantial site at the mouth of the Piscataquis River on the northern side of its confluence with the Penobscot River in an area which is not included in the modern site inventory since professional archaeologists have yet to test this location. Moorehead reports: "At Howland, eight kilometers above Passadumkeag, the Piscataquis River comes into the Penobscot from the west and there is a large Indian site at the junction of these streams. Many objects are picked up there each year but our party was unable to discover a burial ground." (Moorehead 1922:222). Several avocational archaeologists have reported to Petersen that artifacts, including ground stone gouges, can still be found there. It may have been extensively disturbed by various forms of historic development, however. This site is situated in an area where the Corps of Engineers is investigating structural options (flood control dikes) for the reconnaissance report.

After Moorehead, relatively little is known of collecting in the study area and no professional work was conducted until the late 1960s, although continued interest in the local Moorehead complex cemeteries continued. Eight such cemetery sites were reported in the study area in one such comparative account, with others very close by such as the Hathaway site a short distance up the Passadumkeag River from the study area (Smith 1948: Appendix B).

In his few years at the University of Maine (Orono), Dr. Dean Snow initiated the first systematic excavations in the area, working primarily at the Eddington Bend and Hathaway sites in pursuit of additional cemetery remains (Snow 1969, 1975). He also worked at site 74-18 on Indian Island in the study area (see Belcher and Sanger 1988a, 1988b) Soon thereafter, Snow's replacement at the University of Maine (Orono), Dr. David Sanger began longer term and more substantial work in the general area of the central and lower Penobscot River drainage. Sanger's systematic research was focused at the Hirundo and Young sites during the early and middle 1970s, of which only the Young site has been reported in detail thus far (e.g., Borstel 1982; Sanger 1975; Sanger et al. 1977). Although these sites lie outside of the study area proper, they are located on Pushaw Stream which is a tributary of the Stillwater River within the limits of the study area.

Commencing in the early 1980s, Sanger and others began a variety of consulting archaeology projects directly within the present study area. The majority of these projects have been undertaken for Bangor Hydro-Electric Company in advance of the relicensing of the Veazie, Orono, Stillwater, and Milford dams, and before development of the Basin Mills Project on the location of the existing Veazie Dam. Over 85 sites have been identified as the result of these hydro-electric related consulting archaeology projects (e.g., Belcher 1988a, Belcher 1988b; Belcher and Kellogg 1987; Belcher and Sanger 1988a, 1988b, 1988c; Pekrul 1985; Petersen and Sanger 1986; Sanger 1984; Sanger and Pekrul 1985). None of these have progressed to mitigation/data recovery excavations yet, but such work in the near future will greatly contribute to the existing information for several of the more significant of these sites, perhaps including Eddington Bend (74-8) and Blackman Stream (74-19), among others.

Other consulting projects have also been conducted within the study area between Eddington and Milford. The most notable of these is the mitigation excavation of the Collins Bridge site (74-16), where prehistoric cultural deposits were salvaged prior to reconstruction of a culvert near the confluence of Otter Stream and the Penobscot River in Bradley (Sanger et al. 1986). Although much of the site may have been destroyed by this construction, it is important to note that it is located in an area where the Corps of Engineers is considering the benefits of constructing a flood control dike.

The only other portion of the study area which has been the scene of modern archaeological research lies along the Piscataquis River from Dover-Foxcroft to Medford. With the initiation of the Piscataquis Archaeological Project (PAP) in 1984, a variety of consulting archaeology and other research projects have been undertaken by James Petersen and others. Of the consulting projects, most have produced clear evidence of sites included in the study area (e.g., Bartone and Petersen 1987; Petersen and Bartone 1987, 1988; Petersen and Putnam 1987). Likewise, other noncontractual research projects have demonstrated the presence of highly significant sites in the study area, particularly at the confluence of the Sebec and Piscataquis rivers in Milo (e.g., Petersen 1986a, 1986b; Petersen et al. 1906, 1988).

In sum, two portions of the study area have been intensively studied during the past decade, with the identification of numerous significant aboriginal cultural resources in these areas as a result. These areas include the main stem of the Penobscot River between Eddington and Milford and limited portions of the main stem of the Piscataquis River between Dover-Foxcroft and Medford. This combined research well demonstrates the potential density and significance of the other, lesser studied portions of the study area.

CULTURE HISTORY OVERVIEW

As noted above, the known archaeological sites in the study area establish the long term presence of aboriginal populations in the study area from ca. 8300-7000 B.C. onward throughout their recognizable archaeological presence, albeit on the basis of evidence from only a few sites for some portions of the sequence. This evidence is briefly summarized below and in Figure 1.

The Paleoindian period, ca. 9000-7000 B.C., represents the earliest occupation of the study area and elsewhere in central Maine. Unfortunately, little conclusive evidence of the Early Paleoindian period, ca. 9000-8000 B.C., is known anywhere in the Penobscot River drainage. Singular finds of diagnostic fluted points are known from several portions of the broad drainage beyond the study area, including the Schoodic Lake area in the Piscataquis River drainage (Spiess and Wilson 1988) and the Caugomogomac Stream area in the upper West Branch area on the basis of recent relicensing work for Great Northern Paper. A date of ca. 8300 B.C. from the Brigham site at the Sebec-Piscataquis River confluence may represent the only in situ Early Paleoindian site known thus far in the Penobscot River drainage, but diagnostic remains have yet to be associated with it (Petersen 1986a; Petersen et al. 1986).

More recent Late Paleoindian period remains, ca. 8000-7000 B.C., are known from a greater number of find spots and several in situ sites in the study area and the broader drainage of the Penobscot River. The find spots within the study area include Schoodic Point (107-9) and possibly site 90-1, while the Blackman Stream site (74-19) provides the only conclusive evidence of an in situ Late Paleoindian occupation. At Blackman Stream, one parallel flaked projectile point and several pieces of debitage were found stratigraphically 1 m below a later occupational horizon radiocarbon dated at ca. 6400 B.C., 5800 B.C., and 5500 B.C., thus establishing the relative antiquity of the deeper remains (Belcher and Kellogg 1987; Belcher and Sanger 1988c). Other dates of ca. 7000 B.C. and 6800 B.C. from the Sharrow site (90-2D) in Milo are probably attributable to the Late Paleoindian period, but thus far lack diagnostic associations (Petersen et al. 1988). Various other find spots are known within the broader Penobscot River drainage, including the Brockway site (90-3) near the study area on the Sebec River (Bartone et al. 1988), a site on the Pleasant River north of Brownville Junction, others on the the upper West Branch of the Penobscot River (Doyle et al. 1985), and another recently discovered on Millinocket Lake.

The subsequent Archaic period, ca. 7000-1000 B.C., can be generally subdivided into three periods. The earliest of these is the Early Archaic period, ca. 7000-5500 B.C. It is not represented by any unequivocal diagnostic artifacts in the study area or anywhere in the broader Penobscot River drainage as currently known, but several of the dates cited above for the Blackman Stream site (74-19) fall within the expected span of the early Archaic period. Likewise, dates of ca. 6800 B.C., 6300 B.C., and 6000 B.C. from the Sharrow site (90-2D) and ca. 6000 B.C. at the Brigham site (90-2C) in Milo establish a clear presence of the Early Archaic period occupants in the study area (Petersen and Putnam 1987; Petersen et al. 1988).

The Middle Archaic period, dated ca. 5500-4000 B.C., is better represented in the study area and the broader Penobscot River drainage. For example, at least one of the above mentioned dates from the Blackman Stream site and dates of ca. 5500 B.C. from Brigham and 5300 B.C. and 4400 B.C. from Sharrow document unequivocal Middle Archaic period occupations. Of these, none include in situ diagnostic projectile points, but all include other apparently diagnostic tool forms and three such points are known from eroded contexts at the Sharrow site. Diagnostic Middle Archaic period projectile points are known from various other local sites, however, including the Derby site (90-2B), Schoodic Point (107-9), and several sites in the area of the Milford head pond (74-106) and the Basin Mills Project (74-39). Other in situ and surface finds of Middle Archaic period artifacts are known in other portions of the Penobscot River drainage, including several sites on Sebec Lake, on the Sebec River, in the upper West Branch area, Passamagamet Lake, and at the Hirundo site (e.g., Sanger 1975; Sanger et al. 1977).

The Late Archaic period, dated ca. 4000-1000 B.C., is the oldest well represented temporal period in the study area and the broader Penobscot River drainage. It can be subdivided into three more or less sequential traditions or phases/complexes which include the Laurentian, ca. 4000-3000 B.C., the Moorehead, ca. 3000-1800 B.C., and the Susquehanna, ca. 1800-1000 B.C. Although the earliest of these is widely represented, like earlier manifestations it is not particularly common nor is it well dated. The notable exceptions include the Brigham site, where it is dated ca. 3800 B.C., and the Sharrow site, where it is dated ca. 3800 B.C., 3300 B.C., and possibly 2500 B.C. (Petersen and Putnam 1987; Petersen et al. 1986). The later portions of the Late Archaic period, including occupations attributable to the Moorehead complex and the Susquehanna tradition, have been more commonly dated. Some of these sites in the study area include Brigham, Sharrow, and Derby in the Milo area along with Eddington Bend, Ayers Rapids I (74-22), and Ayers Rapids II (74-23) in the Basin Mills Project area (e.g. , Belcher 1988b; Belcher and Sanger 1988c; Petersen and Putnam 1987; Petersen and Sanger 1986; Petersen et al. 1988; Snow 1975). Other late Late Archaic period dates have also been reported for the Brockway site in Milo, the Passadumkeag cemetery, and the Hirundo and young sites on Pushaw Stream, among others (e.g., Bartone et al. 1988; Borstel 1982; Sanger et al. 1977; Snow 1969, 1975).

The subsequent Woodland (Ceramic) period, ca. 1000 B.C.-A.D. 1550, can be likewise subdivided into three periods. These include the Early Woodland (Ceramic), ca. 1000-100 B.C., the Middle Woodland (Ceramic), ca. 100 B.C.-A.D. 1000, and the Late Woodland (Ceramic), ca. A.D. 1000-1550. In many ways, the Woodland (Ceramic) period in the study area and other portions of the interior Penobscot River drainage is less well understood than the preceding Late Archaic period given that relatively few such sites have been studied anywhere away from the Atlantic coast. There are certainly fewer available dates for the Woodland (Ceramic) period in general in the study area and nearby settings.

There are no dated Early Woodland (Ceramic) period sites and relatively few recognizable diagnostic tool and pottery finds thus far, with a few exceptions at the Rhoda (90-2A) and Sharrow sites in Milo, one site in the Milford Project area (74-73), and the Eddington Bend site (e.g., Belcher and Sanger 1988a; Petersen and Sanger 1986). Beyond the study area, such remains are also recognizable at the Young site (Borstel 1982) and various others in the upper West Branch area.

The Middle Woodland (Ceramic) period is much better represented, but still needs additional dates. In the study area, dated Middle Woodland (Ceramic) period occupations occur at the Brigham and Sharrow sites, Eddington Bend, Collins Bridge, site 74-18 on Indian Island, Blackman Stream, and Ayers Rapids I (Belcher and Kellogg 1987; Belcher and Sanger

1988b, 1988c; Petersen et al. 1986, 1988; Sanger et al. 1986). Few other contemporaneous dated occupations are currently available in the broader interior portions of the Penobscot River drainage. However, a relatively large number of Middle Woodland (Ceramic) period occupations can be suggested locally and within the broader area on the basis of diagnostic tools and pottery (e.g., Belcher 1988; Belcher and Sanger 1988a, 1988b, 1988c; Borstel 1982; Petersen and Bartone 1988).

In some ways, the Late Woodland (Ceramic) period is less well represented than the Middle Woodland period, or is less recognizable. The only dated local context is at the Brigham site and few, if any others are currently known within the noncoastal Penobscot River drainage (Petersen et al. 1986). However, undated Late Woodland (Ceramic) period occupations are recognizable at various other local and nearby areas (e.g., Belcher and Sanger 1988a, 1988b, 1988c).

The final archaeologically recognizable period of aboriginal occupation occurred during the Contact period, ca. A.D. 1550-1750. Very few such sites have been confirmed in the local study area or broader region. These only include the Beaver site (74-85), possibly the Eddington Bend site, and site 74-115 (e.g., Belcher and Sanger 1988a, 1988b), but numerous such sites should be present locally on the basis of available documentation of aboriginal habitations in the study area and further up the Penobscot River during the early nineteenth century (Treat 1820).

CULTURAL RESOURCE STATUS SUMMARY

The status of the 185 (+) aboriginal cultural resources currently known within the study area is not particularly well known except for most identified by recent consulting archaeology projects on the Penobscot River between Eddington and Milford as well as some of those known on the Piscataquis River. In fact, using all available information the erosion status of only 97 (52%) of all known sites can be grossly estimated. However, of these 97 sites it is clear that only 14 (14%) are stable or not undergoing erosion using a combination of terms suggested by Belcher and Sanger (1988a:34) arid those employed by University of Maine at Farmington Archaeology Research Center. Fully 66 sites (68%) are undergoing moderate (21 or 22%), moderate to severe (17 or 18%), or severe (28 or 29%) erosion; the balance of the sites (17 or 18%) can be best characterized as being stable to undergoing slight erosion (Table 1). Thus, it is immediately obvious that the large majority of the sites for which information is available are undergoing some degree of erosion. Of course, such erosion threatens the integrity of the sites where it is occurring.

Of further note, a large number of eroding and other stable sites have been and continue to be subject to a variety of other threatening disturbances. Many were once cultivated and in each case, this has disturbed near surficial deposits. In some cases, this circumstance means that intact deposits only survive in sub-plowzone feature remnants, notably including the Eddington Bend site, among some others (Petersen and Sanger 1986). Other impacts include dam construction, logging facilities and once common log drives, episodes of canal, railroad, sewer line, and road construction, gravel pits, and other development activities along the rivers of central Maine. One other considerable threat, looting, is particularly notable given that it represents willful and intentional destruction of cultural resources. Dramatic examples of extensive disturbance caused by looting are minimally demonstrable at sites 90-2B, 107-1, 107-2, 107-9, 74-8, 74-19, and 74-20, among others (e.g., Belcher and Sanger 1988c; Petersen and Sanger 1986).

Finally, it should be reiterated that two aboriginal sites or site remnants could be threatened if the structural alternatives such as dikes or walls under investigation were proposed for the towns of Bradley and Howland. Of these two sites, the first is the Collins Bridge site (74-16) in Bradley which has been the scene of mitigation investigations. The second site is not recorded in the Maine Site Survey files, but was recorded by Moorehead and others since his time. This latter site has never been thoroughly examined by a professional archaeologist, but may have been extensively disturbed by various forms of historic development. A third area where the Corps of Engineers is studying structural alternatives is situated in Dover-Foxcroft. This area has not been studied either and consequently, may or may not contain an aboriginal site or site remnant given the likelihood of historic disturbance in that area in the past.

SUMMARY AND CONCLUSIONS

This brief summary report has documented the existence of over 185 known aboriginal cultural resources within the study area along portions of the Piscataquis and Penobscot rivers in central Maine. This number of aboriginal cultural resources likely only represents a small portion of the overall preserved sample of aboriginal archaeological sites in the study area given the relatively restricted portions of the area that have been more or less intensively studied. Even where consulting archaeology projects have been undertaken on the Penobscot River between Eddington and Milford, excavation of test pits has been typically done rather 'lightly' and so, even in these better studied portions of the study area there may be sites that remain currently unidentified. Elsewhere on the Penobscot and Piscataquis rivers, relatively little research of any sort has been undertaken and consequently, it seems likely that only a very small sample of the sites actually preserved there have been identified to date.

Floodplain alluvial terraces seem to be particularly likely areas for the presence of sites as well as stream junctions and waterfalls, but adjacent areas on higher landforms also seem likely areas. Other settings more distant from water may be also somewhat sensitive, but remain little known due to the lack of survey work in such areas. However, given the concentration of prehistoric sites within the areas in the Penobscot River

Basin which have been intensively studied, this preliminary analysis of available information illustrates that the river's edge and floodplain have been extensively used by prehistoric groups.

In spite of the apparent limitations in the available information, it is obvious that of the known sites a substantial number have undergone or are currently undergoing rather notable erosion. When taken in conjunction with a variety of other past, ongoing, and expected development and land management threats to the currently known resources, the degree of the combined threat to them is rather alarming. The nonrenewable nature of cultural resources makes their loss a matter of grave concern for preservation managers. Each site lost through vandalism or to erosion and other natural forces increases the value of those sites still remaining in the archaeological record. This makes the recording and preserving of prehistoric site information at known sites even more important. Valuable information will be forever lost when these sites are disturbed and destroyed. Action should be taken to minimize or mitigate threats to these resources at the same time that additional effort should be expended to identify other currently unknown sites that may be likewise threatened now or in the future.

Table 1. Summary of information gathered for aboriginal sites located in the project area.

USGS Topo Map Minutes Yr Issued	Maine Site No.	Topographic Setting	Drainage	Erosion Specified*	Type of Site	Cultural Affiliation
Kingsbury 7.5' 1984						
	87-1	terrace	Piscataquis River	yes	unknown	unknown prehistoric
Guilford 7.5' 1984	There are no archaeological sites recorded on this map					
Sangerville 7.5' 1984						
	88-2	terrace	Piscataquis River	yes	unknown	unknown prehistoric
	88-3	terrace	Piscataquis River	no	encampment	unknown prehistoric
Dover-Foxcroft 7.5' 1983						
	89-1	terrace	Piscataquis River	no**	unknown	unknown prehistoric
	89-7	terrace	Piscataquis River	no***	encampment	unknown prehistoric
South Sebec 7.5' 1983						
	89-2	terrace	Piscataquis River	no	encampment	unknown prehistoric
	89-3	terrace	Piscataquis River	no	encampment	unknown prehistoric
	89-4	terrace	Piscataquis River	no	encampment	unknown prehistoric
	89-5	terrace	Piscataquis River	no	encampment	unknown prehistoric
	89-6	terrace	Piscataquis River	no	encampment	unknown prehistoric
Milo South 7.5' 1983						
	90-1	terrace	Piscataquis-Pleasant River confluence	moderate-severe	encampment	minimally Late Archaic
	90-2A	terrace	Piscataquis River	moderate-severe	encampment	minimally Late Archaic/ Late woodland
	90-2B	terrace	Piscaataquis River	moderate-severe	encampment	minimally Middle Archaic/Late Woodland
	90-2C	terrace	Piscataquis River	moderate-severe		Early Paleoindian-Late Woodland
	90-2D	terrace	Piscataquis River	moderate-severe	encampment	Late Paleoindian-Late Woodland
	90-4	terrace	Piscataquis River	no	unknown	unknown prehistoric
	90-5	terrace	Piscataquis-Pleasant River confluence	no	unknown	unknown prehistoric
	90-7	terrace	Piscataquis River	no	encampment	unknown prehistoric
	90-8	terrace	Piscataquis River	stable	encampment	unknown prehistoric
	90-9	terrace	Piscataquis River	no	encampment	unknown prehistoric

Table 1 (cont.)

USGS Topo Map Minutes Yr Issued	Maine Site No.	Topographic Setting	Drainage	Erosion Specified*	Type of Site	Cultural Affiliation
Schoodic 15' 1947						
	107-1	terrace	Piscataquis River	moderate-severe	encampment	Late Archaic-Late Woodland
	107-2	location not specified		moderate-severe	unknown	unknown prehistoric
	107-4	terrace	Piscataquis River	moderate	unknown	Late Archaic-Middle Woodland
	107-5	terrace	Piscataquis River Scutaze Stream confluence	moderate	encampment	unknown prehistoric
	107-8	terrace	Piscataquis River	moderate-severe	encampment	Archaic
	107-9	terrace	Piscataquis River	moderate	unknown	Late Paleoindian-Late Woodland
Lincoln 15' 1957						
	108-1	Mattanawcook Island	Penobscot River	no	unknown	Late Archaic
	108-2	terrace	west side of Piscataquis River-Sebois Stream confluence	no	encampment	Woodland
	108-3	terrace	east side of Piscataquis River-Sebois Stream confluence	no	unknown	unknown prehistoric
	108-5	Mohawk Island	Penobscot River	no	unknown	unknown
	108-6	terrace	Penobscot River	no	unknown	unknown
	108-7	terrace	Penobscot River Matamuscontis Stream confluence	yes	unknown	unknown
	108-8	Gordon Island	Penobscot River	no	encampment	Contact period
	108-9	Mohawk Island	Penobscot River	no	encampment	Contact period
	108-10	Terrace	Penobscot River-Chesley Brook confluence	no	encampment	Contact period
	108-11	terrace	Penobscot River	no	encampment	Contact period
	108-12	Mattanowcook Island	Penobscot River	no	encampment	Contact period
	108-13	Mattanowcook Island	Penobscot River	no	encampment	Contact period
	108-14	terrace	Penobscot River	no	encampment	Contact period

Table 1 (cont.)

USGS Topo Map Minutes Yr Issued	Maine Site No.	Topographic Setting	Drainage	Erosion Specified*	Type of Site	Cultural Affiliation
Passadumkeag 15' 1960						
	91-2	terrace	Penobscot River	very severe	encampment	Late Archaic-Woodland
	91-3	Long Island	Penobscot River	no	encampment	Contact period
	91-4	terrace	Penobscot River-Passadumkeag River confluence	no	cemetery	Archaic-Woodland
	91-6	terrace	Penobscot River-Piscataquis River confluence	no	village-cemetery	Late Archaic-Woodland
	91-7	terrace	Penobscot River	no	unknown	unknown
	91-8	terrace	Penobscot River	no	unknown	unknown
	91-10	Freese Island	Penobscot River	no	encampment	Contact period
	91-11	Freese Island	Penobscot River	no	encampment	Contact period
	91-12	Jackson Island	Penobscot River	no	encampment	Contact period
	91-13	Hemlock Island	Penobscot River	no	encampment	Contact period
	91-14	Buck Islands	Penobscot River	no	encampment	Contact period
	91-15	Sugar Island	Penobscot River	no	encampment	Contact period
	91-16	Olanon Island	Penobscot River	no	encampment	Contact period
	91-17	Olanon Island	Penobscot River	no	encampment	Contact period
	91-18	terrace	Penobscot River-Olanon Stream confluence	no	encampment	Contact period
	91-19	Grass Island	Penobscot River	no	encampment	Contact period
	91-20	Nicolar Island	Penobscot River	no	encampment	Contact period
	91-21	Craig Island	Penobscot River	no	encampment	Contact period
	91-22	terrace	Penobscot River	no	encampment	Contact period
	91-23	Thoroughfare Island	Penobscot River	no	encampment	Contact period

Table 1 (cont.)

USGS Topo Map Minutes Yr Issued	Maine Site No.	Topographic Setting	Drainage	Erosion Specified*	Type of Site	Cultural Affiliation
Orono 15' 1955						
	74-1	terrace	Penobscot River	no	cemetery	Late Archaic
	74-2	terrace	Penobscot River	no	encampment	Late Archaic
	74-3	Marsh Island	Penobscot River	unknown	unknown	unknown
	74-5	terrace	Penobscot River	unknown	unknown	unknown
	74-6	terrace	Penobscot River	unknown	unknown	unknown
	74-7	terrace	Penobscot River	unknown	unknown	unknown
	74-8	terrace	Penobscot River	moderate?	encampment-cemetery	Late Archaic-Contact period
	74-9	terrace	Penobscot River	unknown	unknown	unknown
	74-10	terrace	Sunkhaze Stream	unknown	unknown	unknown
	74-11	Indian Island	Penobscot River	unknown	unknown	unknown
	74-12	Indian Island	Penobscot River	unknown	unknown	unknown
	74-13	terrace	Penobscot River	unknown	unknown	unknown
	74-14	terrace	Penobscot River-Sunkhaze Stream confluence	stable	encampment	Archaic-Woodland
	74-15	terrace	Penobscot River-Sunkhaze Stream confluence	stable	encampment	Middle to Late Archaic
	74-16	terrace	Penobscot River-Otter Stream confluence	moderate	encampment	Middle Woodland
	74-17	Marsh Island	Stillwater River	not noted	unknown	unknown prehistoric
	74-18	Indian Island	Penobscot River	stable-moderate	encampment cemetery	Archaic-Contact period
	74-19	terrace	Penobscot River-Blackman Stream confluence	moderate	encampment	Late Paleoindian-Middle Woodland
	74-20	terrace	Penobscot River-Blackman Stream confluence	severe	encampment	Late Archaic-Late Woodland
	74-21	terrace	Penobscot River	unknown	unknown	unknown
	74-22	terrace	Penobscot River-unnamed stream confluence	moderate	encampment	Late Archaic-Middle Woodland
	74-23	terrace	Penobscot River	stable	encampment	Late Archaic-Middle Woodland
	74-24	terrace	Penobscot River	unknown	unknown	unknown
	74-25	Marsh Island	Penobscot River	unknown	unknown	unknown
	74-26	terrace	Penobscot River	unknown	unknown	unknown
	74-27	terrace	Penobscot River	unknown	unknown	unknown
	74-28	terrace	Penobscot River	unknown	unknown	unknown
	74-29	terrace	Penobscot River	unknown	unknown	unknown

Table 1 (cont.)

USGS Topo Map Minutes Yr Issued	Maine Site No.	Topographic Setting	Drainage	Erosion Specified*	Type of Site	Cultural Affiliation
	74-30	terrace	Penobscot River-Eaton Brook confluence	unknown	unknown	unknown
	74-31	terrace	Penobscot River	unknown	unknown	unknown
	74-32	terrace	Eaton Brook	unknown	unknown	unknown
	74-33	terrace	Penobscot River	unknown	unknown	unknown
	74-34	terrace	Penobscot River	no	unknown	unknown prehistoric
	74-35	terrace	Penobscot River	unknown	unknown	unknown
	74-36	terrace	Penobscot River	unknown	unknown	unknown
	74-37	terrace	Penobscot River	unknown	unknown	unknown
	74-38	terrace	Penobscot River	unknown	unknown	unknown
	74-39	terrace	Penobscot River-unnamed stream confluence	stable	unknown	Middle Archaic-Middle Woodland
	74-40	Marsh Island	Penobscot River	no	encampment	Middle Woodland
	74-42	Orson Island	Penobscot River	no	encampment	Contact period
	74-43	terrace	Penobscot River	no	encampment	Contact period
	74-44	terrace	Penobscot River	severe	encampment	unknown prehistoric
	74-46	terrace	Penobscot River	moderate-severe	encampment	unknown prehistoric
	74-47	terrace	Penobscot River	no	unknown	unknown prehistoric
	74-48	terrace	Penobscot River-unnamed stream confluence	no	encampment	unknown prehistoric
	74-49	terrace	Penobscot River	moderate	encampment	unknown prehistoric
	74-50	unnamed island	Stillwater River	moderate-severe	encampment	Late Archaic-Woodland
	74-51	Marsh Island	Stillwater River	severe	unknown-redeposited	Archaic-Woodland
	74-52	terrace	Stillwater River	no	unknown	unknown prehistoric
	74-53	terrace	Penobscot River	stable	encampment	Late Archaic?
	74-54	terrace	Penobscot River	severe	unknown	unknown prehistoric
	74-55	terrace	Penobscot River	no	unknown	unknown prehistoric
	74-56	terrace	Penobscot River	moderate-severe	unknown	unknown prehistoric
	74-57	terrace	Penobscot River	moderate	unknown	unknown prehistoric
	74-58	terrace	Penobscot River	stable-moderate	unknown	unknown prehistoric
	74-59	terrace	Penobscot River	no	encampment	Archaic?
	74-60	terrace	Penobscot River	severe	encampment	unknown prehistoric
	74-61	terrace	Penobscot River-unnamed stream confluence	severe	encampment	Archaic-Woodland
	74-62	terrace	Stillwater River	stable	unknown	unknown prehistoric
	74-63	terrace	Stillwater River	moderate	unknown	unknown prehistoric
	74-64	Marsh Island	Stillwater River	moderate	unknown	unknown prehistoric
	74-65	Marsh Island	Stillwater River	stable	encampment	unknown prehistoric

Table 1 (cont.)

USGS Topo Map Minutes Yr Issued	Maine Site No.	Topographic Setting	Drainage	Erosion Specified*	Type of Site	Cultural Affiliation
	74-66	Marsh Island	Stillwater River	moderate-severe	unknown-redeposited	unknown prehistoric
	74-67	Marsh Island	Stillwater River	severe	unknown	unknown prehistoric
	74-68	Marsh Island	Stillwater River	severe	unknown	Archaic-Woodland
	74-69	Marsh Island	Stillwater River	stable-moderate	unknown	Archaic
	74-70	Marsh Island	Stillwater River	stable-moderate	encampment	unknown prehistoric
	74-71	Marsh Island	Stillwater River	severe	unknown	unknown prehistoric
	74-72	terrace	Penobscot River	stable-moderate	unknown	unknown prehistoric
	74-73	terrace	Penobscot River	stable-moderate	encampment	Early Woodland and Middle Woodland
	74-74	Marsh Island	Penobscot River-Stillwater River confluence	stable-moderate	unknown	unknown prehistoric
	74-75	terrace	Penobscot River	severe	unknown	unknown prehistoric
	74-76	terrace	Penobscot River	stable-moderate	unknown	unknown prehistoric
	74-77	terrace	Penobscot River	severe	unknown	unknown prehistoric
	74-78	terrace	Penobscot River	no	unknown	unknown prehistoric
	74-79	terrace	Penobscot River	stable	unknown	unknown prehistoric
	74-80	terrace	Stillwater River	stable	unknown	unknown prehistoric
	74-81	terrace	Stillwater River	severe	unknown	unknown prehistoric
	74-82	terrace	Stillwater River	stable-moderate	unknown	unknown prehistoric
	74-83	terrace	Stillwater River	moderate	unknown	unknown prehistoric
	74-84	terrace	Stillwater River	moderate	unknown	unknown prehistoric
	74-85	terrace	Stillwater River	severe	encampment	Archaic-Contact period
	74-86	terrace	Stillwater River	severe	unknown	unknown prehistoric
	74-87	terrace	Stillwater River	no	unknown	Woodland
	74-88	terrace	Stillwater River-Birch Stream confluence	severe	unknown	unknown prehistoric
	74-90	terrace	Penobscot River	severe	encampment	unknown prehistoric
	74-91	terrace	Penobscot River	moderate-severe	encampment	Archaic-Late Woodland
	74-92	terrace	Penobscot River	moderate	unknown	unknown prehistoric
	74-93	terrace	Penobscot River	moderate-severe	unknown	unknown prehistoric
	74-94	Twin Island	Stillwater River	moderate-severe	unknown	unknown prehistoric
	74-95	Orson Island	Stillwater River	severe	unknown	unknown prehistoric
	74-96	Orson Island	Stillwater River	severe	unknown	unknown prehistoric
	74-97	unnamed island	Stillwater River	severe	unknown	unknown prehistoric
	74-98	Orson Island	Penobscot River	severe	unknown	unknown prehistoric

Table 1 (cont.)

USGS Topo Map Minutes Yr Issued	Maine Site No.	Topographic Setting	Drainage	Erosion Specified*	Type of Site	Cultural Affiliation
	74-99	Orson Island	Penobscot River	stable-moderate	unknown	Woodland
	74-100	Orson Island	Penobscot River	moderate-severe	unknown	Archaic-Woodland
	74-101	Orson Island	Stillwater River	stable-moderate	unknown	unknown prehistoric
	74-102	Orson Island	Stillwater River	stable-moderate	unknown	unknown prehistoric
	74-103	Indian Island	Penobscot River	severe	unknown	unknown prehistoric
	74-104	Indian Island	Penobscot River	severe	unknown	unknown prehistoric
	74-105	Indian Island	Penobscot River	severe	encampment	Late Archaic-Middle Woodland
	74-106	terrace	Stillwater River	severe	unknown	Middle Archaic-Middle Woodland
	74-107	unnamed island	Stillwater River	moderate-severe	encampment	unknown prehistoric
	74-108	Indian Island	Penobscot River	moderate	unknown	unknown prehistoric
	74-109	Indian Island	Penobscot River	moderate?	unknown	unknown prehistoric
	74-110	Indian Island	Penobscot River	moderate-severe	unknown	Archaic
	74-111	Indian Island	Penobscot River	moderate	encampment	unknown prehistoric
	74-112	Orson Island	Penobscot River	stable-moderate	unknown	unknown prehistoric
	74-113	unnamed island	Stillwater River	stable-moderate	unknown	unknown prehistoric
	74-114	Orson Island	Stillwater River	severe	unknown	unknown prehistoric
	74-115	Orson Island	Stillwater River	stable-moderate	unknown	Contact period
	74-116	unnamed island	Penobscot River-Stillwater River confluence	moderate	unknown	unknown prehistoric
	74-117	Indian Island	Penobscot River	moderate	unknown	unknown prehistoric
	74-118	Indian Island	Penobscot River	moderate	unknown	unknown prehistoric
	74-119	Indian Island	Penobscot River	stable-moderate	unknown	unknown prehistoric
	74-120	terrace	Stillwater River-Birch Stream confluence	moderate	unknown	unknown prehistoric
	74-121	terrace	Penobscot River	stable-moderate	unknown	Woodland
	74-122	Orson Island	Penobscot River	stable	unknown	unknown prehistoric
	74-123	Orson Island	Penobscot River	stable	unknown	Archaic
	74-125	terrace	Penobscot River	stable	unknown	unknown prehistoric
	74-126	terrace	Penobscot River	stable	unknown	Late Archaic
	74-127	terrace	Penobscot River	severe	unknown	unknown prehistoric

Table 1 (cont.)

USGS Topo Map Minutes Yr Issued	Maine Site No.	Topographic Setting	Drainage	Erosion Specified*	Type of Site	Cultural Affiliation
Bangor 7.5' 1978						
	73-2	terrace	Penobscot River-Kenduskeag Stream confluence	no	unknown	unknown
	73-3	terrace	Penobscot River	no	unknown	unknown
	73-4	terrace	Penobscot River	no	unknown	unknown
	73-5	terrace	Penobscot River	no	unknown	unknown

* Erosion has been noted on many of the site forms on file at the Maine Historic Preservation Commision but the overall degree of general site erosion frequently has not been noted. All erosion noted for archaeological sites on the Orono 15' topographic map is recorded following the scale recorded by Belcher and Sanger (1988a:34). All others as noted on site forms and/or determined by the authors.

** Appears to have been severely impacted or destroyed by the construction of septic ponds associated with a tannery.

*** At least partially destroyed by the construction of the Dover-Foxcroft Wastewater Treatment Facility.

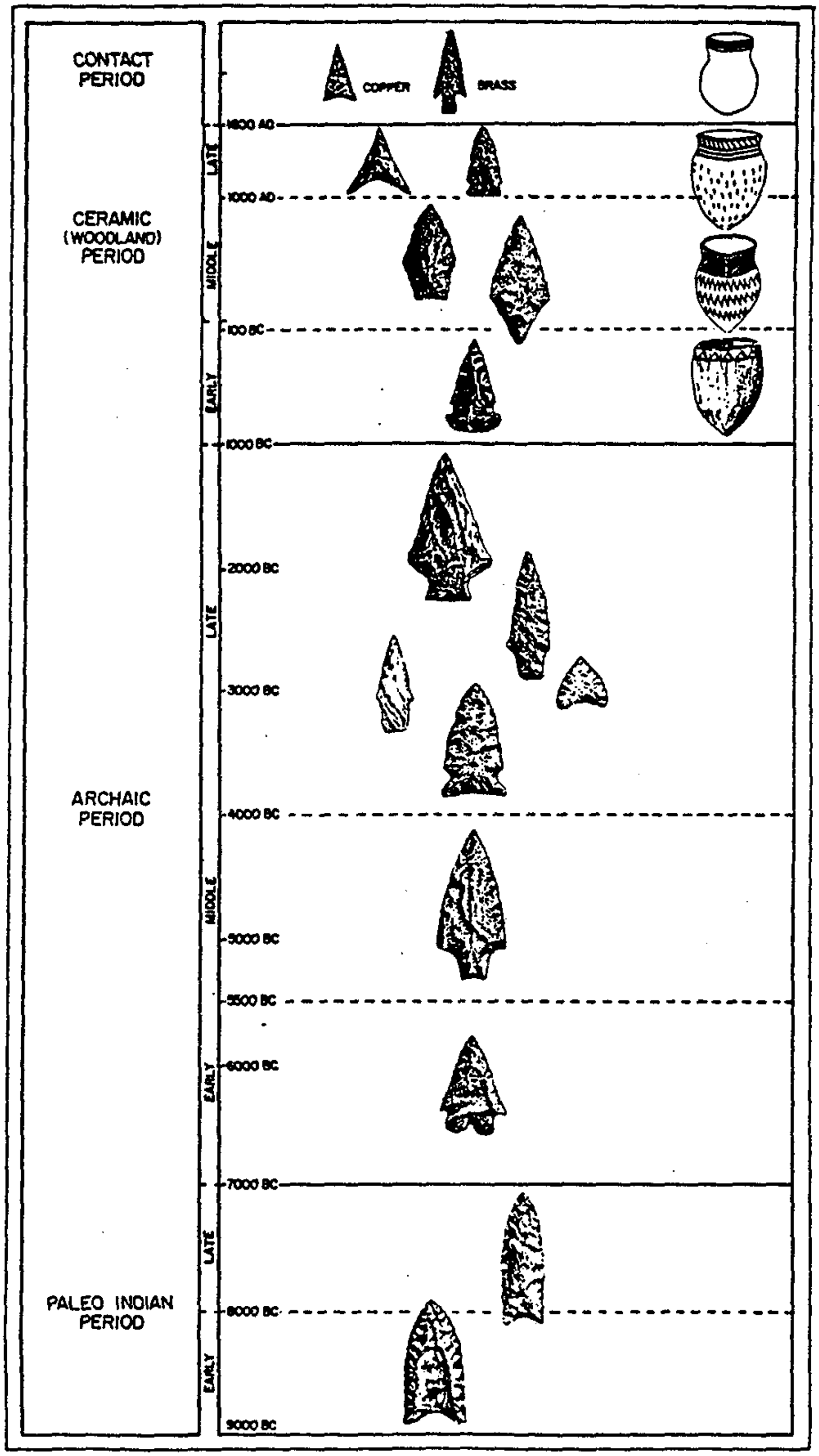


Figure 1. Cultural time line for Maine aboriginal prehistory and history.

REFERENCES CITED

Bartone, Robert N., and James B. Petersen

1987 Archaeological Phase I Survey and Testing of the Proposed Dover-Foxcroft Wastewater Treatment Facility, Dover-Foxcroft, Maine. University of Maine at Farmington Archaeology Research Center. Submitted to the Town of Dover-Foxcroft.

Bartone, Robert N., David E. Putnam, and James B. Petersen

1988 Archaeological Investigations at the Brockway Site in Central Maine. Current Research in the Pleistocene 5:1-3.

Belcher, William R.

1988a An Assessment of the Cultural Resources in the Veazie and Orono Headponds: Results of the 1987 Phase I Survey. University of Maine Institute for Quaternary Studies and Department of Anthropology. Submitted to Bangor Hydro-Electric Company, Bangor.

1988b Lower Penobscot Valley Archaeology: Field Work in 1988. Maine Archaeological Society Newsletter 2(2) 4-7.

Belcher, William R., and David Sanger

1988a Phase I Archaeological Research in the Stillwater and Milford Reservoirs. University of Maine Institute for Quaternary Studies and Department of Anthropology. Submitted to Bangor Hydro-Electric Company, Bangor.

1988b Phase II Report on the Archaeology of the Milford Reservoir. University of Maine Institute for Quaternary Studies and Department of Anthropology. Submitted to Bangor Hydro-Electric Company, Bangor.

1988c Phase II Report on the Archaeology of the Basin Mills Project. University of Maine Institute for Quaternary Studies and Department of Anthropology. Submitted to Bangor Hydro-Electric Company, Bangor.

Belcher, William, and Douglas Kellogg

1987 Penobscot Valley Archaeological Program: Field Work in 1987. Maine Archaeological Society Newsletter 1(2):3-5.

Borstel, Christopher L.

1982 Archaeological Investigations at the Young Site, Alton, Maine. Occasional Publications in Maine Archaeology 2. Maine Historic Preservation Commission, Augusta.

Doyle, Richard A., Nathan D. Hamilton, James B. Petersen, and David Sanger

1985 Late Paleo-Indian Remains from Maine and Their Correlations in Northeastern Prehistory. Archaeology of Eastern North America 13:1-34.

Moorehead, Warren K.

1922 A Report on the Archaeology of Maine. Department of Anthropology, Phillips Academy, Andover.

Pekrul, Sharon
1985 Phase II Archaeological Investigations in the Basin Mills Project Area. University of Maine Institute for Quaternary Studies and Department of Anthropology. Submitted to Bangor Hydro-Electric Company, Bangor.

Petersen, James B.
1986a A Late Pleistocene and Holocene Archaeological Sequence in Central Maine. Current Research in the Pleistocene 3:16-19.
1986b Archaeological Investigations in the Piscataquis River Drainage and the Greater Moosehead Lake Region, Maine: 1984-1985. University of Maine Archaeology Research Center. Submitted to the Maine Historic Preservation Commission, Augusta.

Petersen, James B., Thomas R. Baker, and Michael J. Heckenberger
1988 A Stratigraphic Sequence at the Sharrow Site in Central Maine. Current Research in the Pleistocene 5:19-20.

Petersen, James B., and Robert N. Bartone
1987 Archaeological Phase I Survey and Phase II Testing of the Proposed Milo Wastewater Treatment Facilities in the Town of Milo, Piscataquis County, Maine. University of Maine at Farmington Archaeology Research Center. Submitted to the Town of Milo and A. E. Hodson Engineers.
1988 An Archaeological Phase I Survey of the Proposed Little Schoodic Landing Project, Medford, Piscataquis County, Maine. University of Maine at Farmington Archaeology Research Center. Submitted to the Patten Auction and Land Corporation, Bangor.

Petersen, James B., Nathan D. Hamilton, David E. Putnam, Arthur E. Spiess, Robert Stuckenrath, Cynthia A. Thayer, and Jack A. Wolford
1986 The Piscataquis Archaeological Project: A Late Pleistocene and Holocene Occupational Sequence in Northern New England. Archaeology of Eastern North America 14: 1- 18.

Petersen, James B., and David E. Putnam
1987 Another Holocene Sequence and Recent Progress of the Piscataquis Archaeological Research in Central Maine. Current Research in the Pleistocene 4:23-24.

Petersen, James B., and David Sanger
1986 Archaeological Phase II Testing at the Eddington Bend Site (74-8), Penobscot County, Maine. University of Maine, Orono. Submitted to the Bangor Hydro-Electric Company, Bangor.

Sanger, David
1975 Culture Change as an Adaptive Process in the Maine-Maritimes Region. Arctic Anthropology 12(2) 60-75.
1984 An Evaluation of the Cultural Resources in the Basin Mills Study Area. University of Maine Institute for Quaternary Studies and Department of Anthropology. Submitted to E. C. Jordan Company, Boston.

Sanger, David, Ronald B. Davis, Robert G. MacKay, and Harold W. Borns
1977 The Hirundo Archaeological Project -- An Interdisciplinary Approach to Central Maine Prehistory. In Amerinds and Their Paleoenvironments in Northeastern North America, edited by W. Newman and B. Salwen, pp. 457-471. Annals of New York Academy of Sciences 288.

Sanger, David, and Sharon Pekrul
1985 Report on 1984 *Archaeological Investigations in the Basin Mills* Project Area. University of Maine Institute for Quaternary Studies and Department of Anthropology. Submitted to Bangor Hydro-Electric Company, Bangor.

Sanger, David, Sharon Pekrul, and Thomas Lowell
1986 *Archaeology of the Collins Bridge Site, Bradley, Maine. Maine* Archaeological Society Bulletin 26(2):5-14.

Smith, Benjamin L.
1948 An Analysis of the Maine Cemetery Complex. Bulletin of the Massachusetts Archaeological Society 9(2&3):20-71.

Smith, Walter B.
1926 Indian Remains of the Penobscot Valley and Their Significance. *University of Maine Studies Second Series 7.* Orono.

Snow, Dean R.
1969 A Summary of Excavations at the Hathaway Site in Passadumkeag, Maine, 1912 1947 and 1968. Ms. on file, Department of Anthropology, University of Maine, Orono.
1978 Eastern Abenaki. In Northeast, edited by Bruce G. Trigger, pp. 137-147. Handbook of North American Indians, vol. 15, William G. Sturtevant, general editor. Smithsonian Institution, Washington, D.C.

Spiess, Arthur E., and Deborah Brush *Wilson*
1988 Michaud, A Paleoindian Site in the New England-Maritimes Region. Occasional Publications in Maine Archaeology 6. Maine Historic Preservation Commission and Maine Archaeological Society.

Treat, J.
1820 Journal and Plans of Survey. Unpublished manuscript on file. Maine Historic Preservation Commission, Augusta.

Appendix E

General Non-Structural Methods

GENERAL NONSTRUCTURAL METHODS

TABLE OF CONTENTS

FLOODPROOFING MEASURES

Floodproofing, by definition, is a body of techniques for preventing damages due to floods, requiring adjustments both to structures and to building contents, and it involves keeping water out as well as reducing the effects of water entry. Such adjustments can be applied by the individual or as part of a collective action either when buildings are under construction or during remodeling or expansion of existing structures. They may be permanent or temporary.

Floodproofing, like other methods of preventing flood damages, has its limitations. It can generate a false sense of security and discourage the development of needed flood control and other actions. Indiscriminately used, it can tend to increase the unwise use of flood plains resulting from unregulated floodplain development.

A floodproofing program would normally warrant serious consideration in the following circumstances:

- Where floodproofing is the most economically feasible solution;
- Where flood control projects are not feasible due to environmental, social or economic reasons;
- Where reduced flood risk could lead to more favorable flood insurance rates; and
- Where existing flood control projects provide only partial flood protection.

Floodproofing measures can be classified into three broad categories. First, there are permanent measures which become an integral part of the structure or land surrounding it. Second, there are temporary or standby measures which are used only during floods, but which are constructed and made ready prior to any flood threat. Third, there are emergency measures which are carried out during flood situations in accordance with a predetermined plan.

Only the first two types of measures will be discussed in the following sections, which will focus on their use in existing structures located in flood hazard areas.

In recent years, floodproofing measures have generally come to be known as "nonstructural" to distinguish them from so called "structural" measures, traditionally associated with major flood control works. The two names are used interchangeably in the presentation of individual types of measures that follow. Although numerous measures exist, depending upon the degree of protection to be provided, the following nonstructural measures are discussed in detail:

. Installation of temporary or permanent closures for openings in existing structures.

. Raising of existing structures in place.

. Rearrangement or protection of damageable property within an existing structure.

. Relocation of existing structures from a flood hazard area.

a. Temporary and Permanent Closures For Openings in Existing Structures

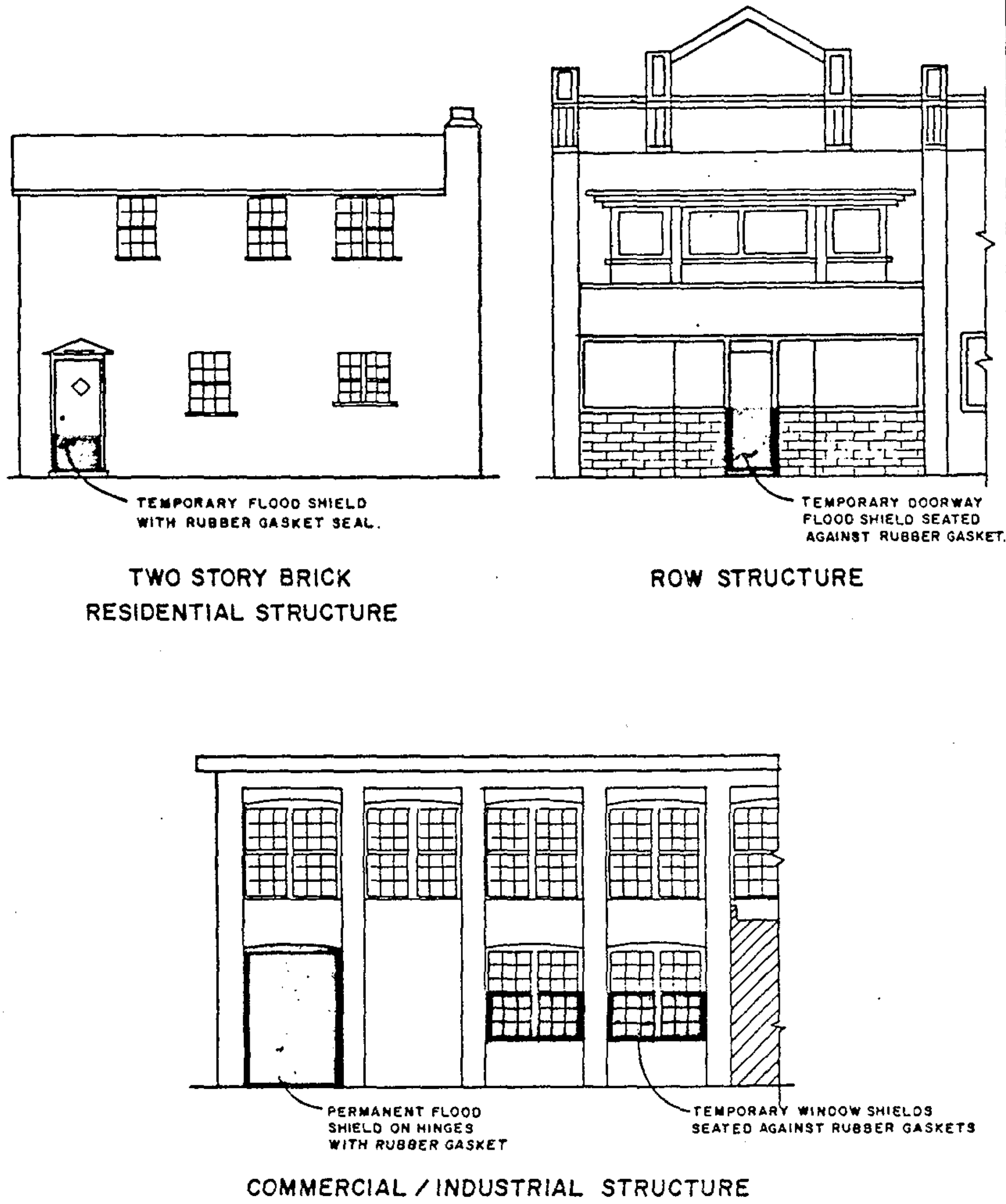
Structures whose exteriors are generally impermeable to water can be designed to keep floodwaters out by installing watertight closures to openings such as doorways and windows as shown on Figure E-1. While some seepage will probably always occur, it can be reduced by applying sealants to walls and floors and providing floor drains where practical. Closures may be temporary or permanent. Temporary closures are installed only during a flood threat and therefore need warning time before installation. Specific measures which may be undertaken are described below.

Doorway Closures - To prevent seepage around exterior doors, installation of some form of floodproofing is required. One of these is flood shields. Shields are normally fabricated of aluminum steel, or wood and made to the height and width desired. In commercial/industrial structures they may be permanently installed on hinges or rollers for swinging or sliding into place or, more often and particularly for residential structures, they may be stored nearby for installation during a time of flood. Doorways not needed may be permanently closed in with masonry or other relatively impermeable materials.

Window Closures - Normal window glass will take little hydrostatic pressure and is especially vulnerable to breakage by floating debris. Flood shields are commonly used to protect windows and prevent water from entering the structure. They may be permanently installed on hinges or rollers at the window opening or stored elsewhere and installed temporarily during floods. Windows not needed can be permanently closed in with masonry or other impermeable materials.

Floodproofing measures such as waterproofing sealants are sometimes applied to generally impermeable floors and walls to further reduce seepage. Sewer lines and other plumbing facilities can be floodproofed by installing backflow valves, gate valves and floor drains equipped with backflow prevention features.

Some seepage is likely to enter a structure even though it is made generally watertight so sump pumps should be available to remove seepage that might occur. The pump discharge should be installed above the expected level of flooding.



Temporary and Permanent Closures

FIGURE E-1

The above measures are those generally used to keep water out of a structure. They can be used in any combination depending on specific site conditions.

<u>Physical Feasibility</u>. Most structures, whether residential, commercial or industrial, are not designed to withstand hydrostatic pressure on the exterior walls. Therefore, when discussing physical feasibility the principal considerations are that (1 the exterior walls are impermeable or can be made so, (2) all openings below the design level can be closed, and (3) the structure can withstand anticipated hydrostatic pressures including buoyancy.

Structures with exterior walls constructed of masonry materials are relatively impermeable and can be made more so by sealing exterior surfaces. Such structures are particularly suited to keeping out water and the only adjustments necessary are to minimize seepage through walls and floors with waterproofing materials and closing of doorways, windows and plumbing lines. Structures with sidings of generally permeable materials are difficult to floodproof to the extent of keeping water out. Even for structures constructed of relatively impermeable materials, the condition of the structure and the number, location, and size of opening influence the feasibility of providing closures.

When water is prevented from entering a structure the walls become subject to lateral and hydrostatic forces which may cause buckling or flotation. Most structures are not designed to carry these forces and consequently are in danger of collapse or floating if floodwaters rise too high. It is particularly difficult to analyze the capability of existing structures to resist these forces because of the general lack of knowledge about workmanship and materials used during construction and about the present condition of these materials.

Advantages

. Floodproofing may be done on a selective basis to only those openings through which water enters and only to the height desired.

. Easy and quick to implement.

. For large commercial and industrial type structures, this may be the most important nonstructural means of flood damage reduction.

Disadvantages

. Applicable only to structure with brick or masonry type walls and without basement, which can structurally withstand the hydrostatic and uplift pressure of the design flood and which are generally watertight.

. Reduced likelihood of effective closure at nights and during vacations with temporary closures.

. May create a false sense of security and induce people to stay in the structure longer than they should.

b. Raising Existing Structures

Existing structures in flood hazard areas can often be raised in place to a higher elevation to reduce the susceptibility of the structures to flood damage as shown on Figure E-2.

Physical Feasibility. Technology exists to raise almost any structure. From a practical viewpoint, raising-in-place is most applicable to structures which can be raised by low-cost conventional means. Generally, this means structures that (1) are accessible below the first-floor level, (2) are light enough to be raised with conventional house-moving equipment, and (3) do not need to be partitioned prior to raising. Wood-frame residential and light commercial structures with first floors above grade are particularly suited for raising.

Structures with concrete floor slabs (slab-on-grade) and structures with common walls are not feasible to raise without special equipment involving additional expense.

Advantages

. Damage to structure and contents is reduced for floods below the raised first floor elevation.

. Particularly applicable to single and two-story frame structures on raised foundations.

. Structures have been raised to heights up to nine feet. The greater heights are probably most acceptable in wooded areas of steep topography.

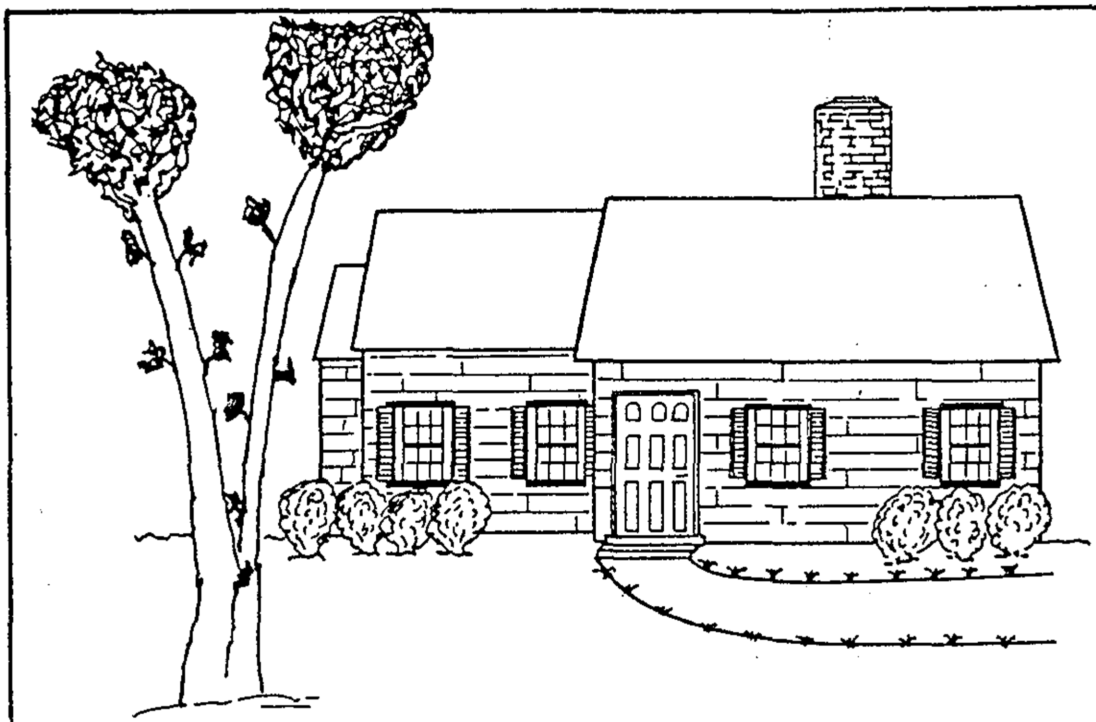
. The means of raising a structure are well known and contractors are readily available.

. Raising in-place allows the owner/user to continue living/working at the existing location.

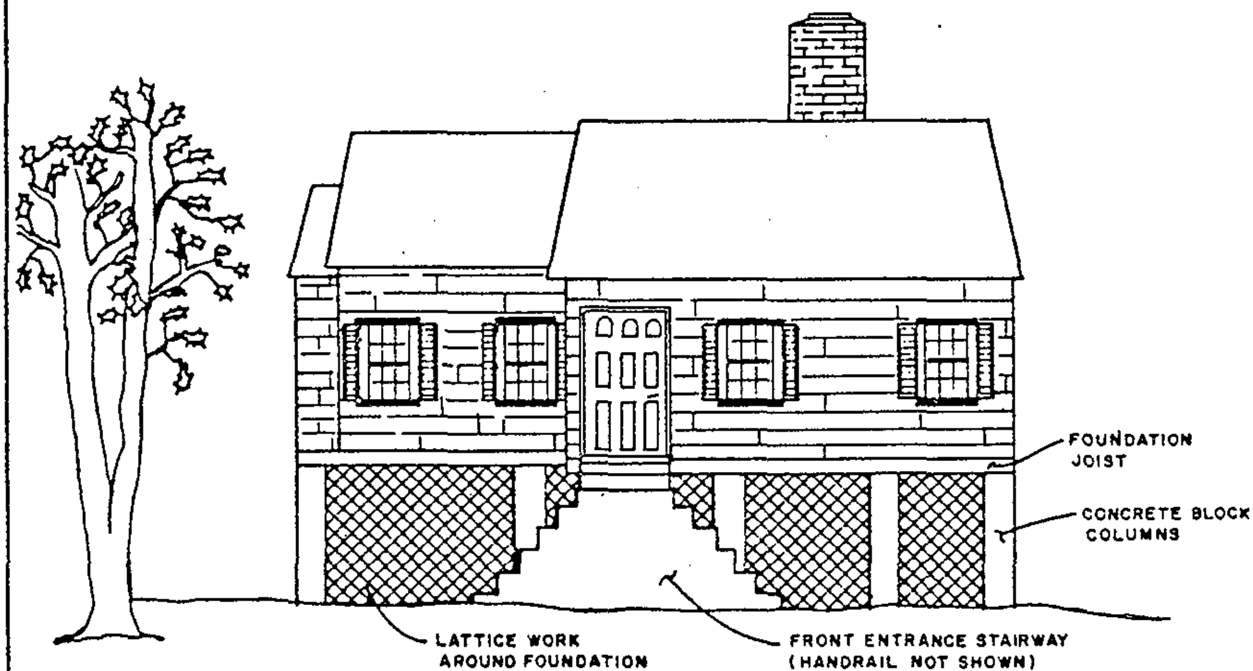
Disadvantages

. Residual damages exist when floods exceed the raised first floor elevation. Minor damage may occur below the first floor depending upon use.

. Not generally feasible for structures with slab-on-grade foundations or structures with basements (unless basement flooding is tolerated).



RESIDENCE BEFORE RAISING



RESIDENCE AFTER RAISING

Raising Existing Structure

FIGURE E-2

. Landscaping and terracing may be necessary if the height raised is extensive.

c. Rearranging or Protecting Damageable Property Within an Existing Structure

Within an existing structure or group of structures damageable property can often be placed in a less damageable location or protected in-place. It is something every property owner can do to one degree or another, depending upon the type and location of damageable property and upon the severity of the flood hazard as shown in Figure E-3.

Examples of this type of action are described as follows:

. Protecting furnaces and appliances by raising them off the floor. This may be appropriate for shallow flooding conditions.

. Relocating damageable property to higher floors.

. Relocating commercial and industrial finished products, merchandise and equipment to a higher floor or adjacent and higher buildings.

. Relocating finished products, materials, equipment and other moveable items located outside a structure to an adjacent, less floodprone site.

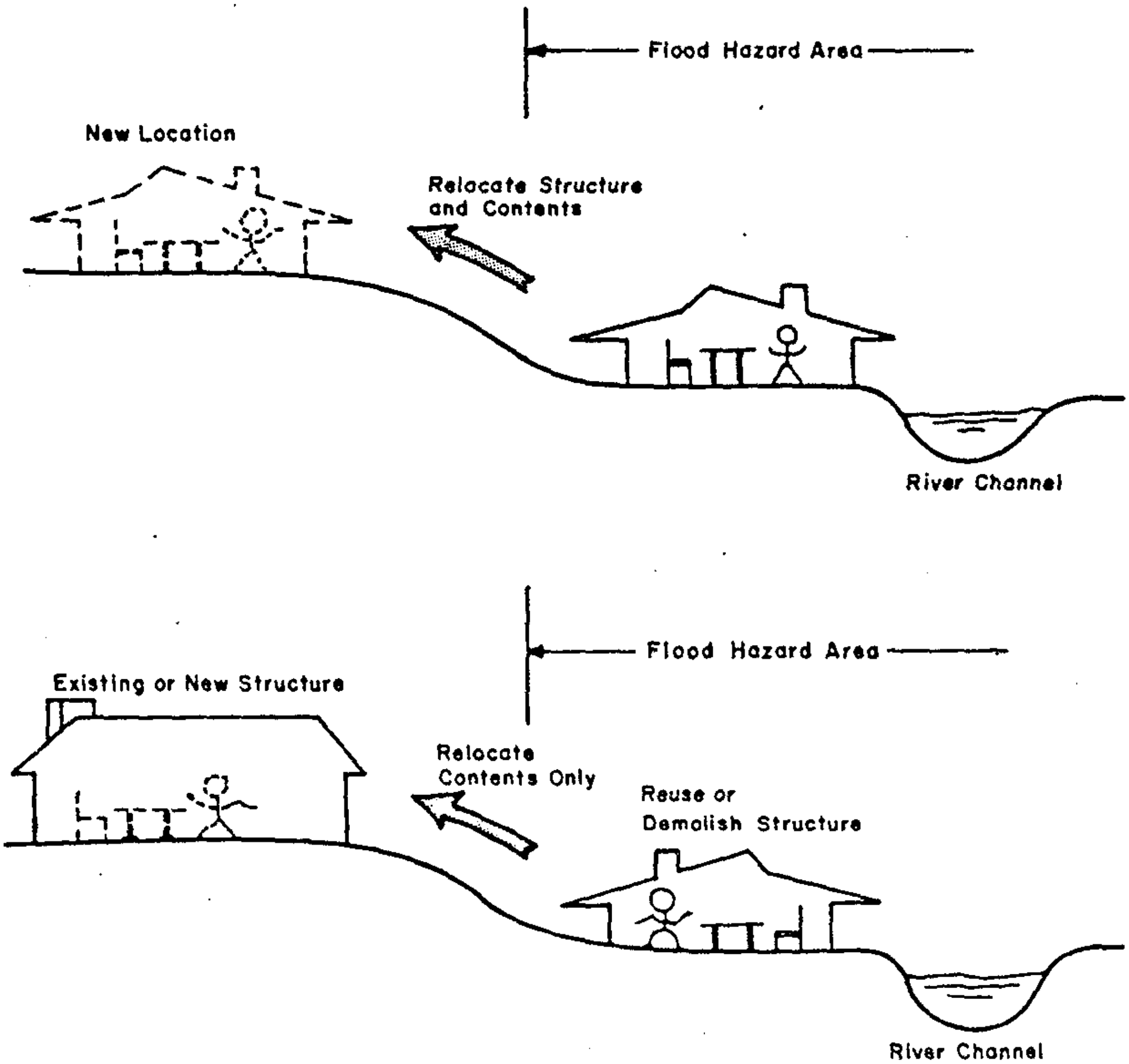
. Protecting commercial/industrial equipment by placing them on a pedestal, table or platform.

. Anchoring all property which might be damaged by movement from floodwaters.

. Protecting important mechanical and electrical equipment by inclosing them in a watertight utility cell or utility room.

Physical Feasibility. The degree to which property can be rearranged and protected is site specific. It depends on the flood hazard, principally depth and frequency of flooding; upon the damageable property, its type, value, location and moveability; upon the availability and adaptability of adjacent, less flood-prone locations; and upon whether the rearrangement can be maintained over a succession of flood-free years. Shallow flooding allows the use of protective types of measures where appliances, utilities, equipment and goods can be raised in-place and protected. Where the hazard is more severe and inundation is to greater depths, property will need to be relocated to prevent damage.

Residual damage to both structure and contents will remain even when property is rearranged or protected. For these reasons, protection of property seems to be given most serious consideration when other measures are either not physically or economically feasible or the depth of flooding is relatively shallow.



Removal of Existing Structure and/or Contents

FIGURE E-3

Advantages

. Most any residential, commercial or industrial property owner can do this to one degree or another.

. It can be done on a per item basis thus reducing the cost and allowing selective protection of high value contents.

. A structure can continue to be used at its existing site.

Disadvantages

Damage can be reduced only on those items which can be relocated or protected.

. A potential residual damage to the structure and contents not relocated or protected remains.

. New patterns must be established for relocated property.

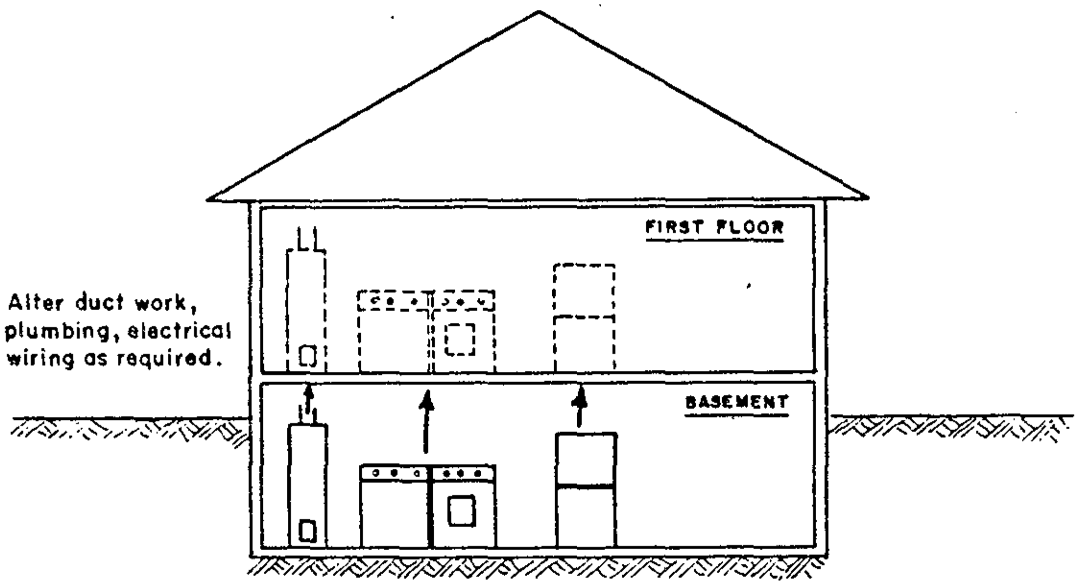
d. <u>Relocation of Existing Structures and/or Contents From a Hazard Area</u>

There are basically two options for removing property to a location outside the flood hazard area. One option is to remove both structure and contents to a flood-free site; the second is to remove only the contents to a structure located out of the flood hazard area and demolish or reuse the structure at the existing site within the flood plain. Each of these options is shown in Figure E-4.

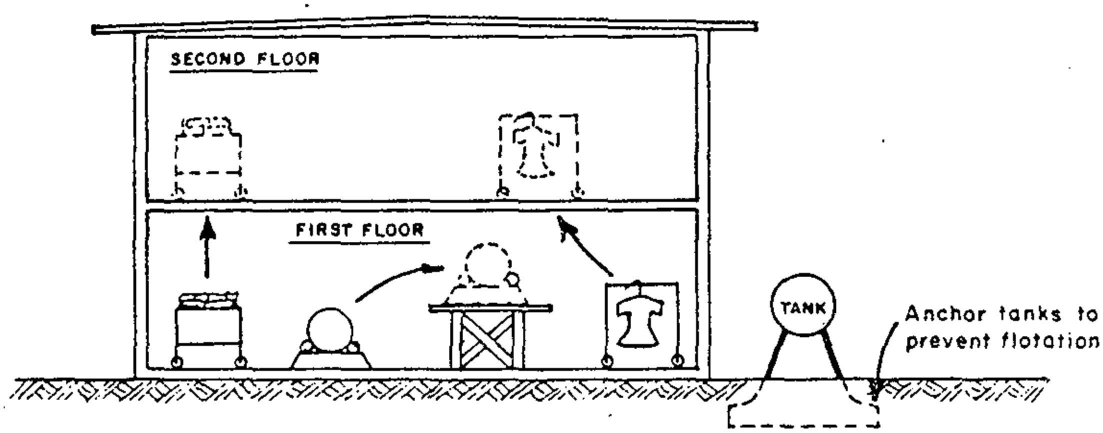
If the structure is reused, it should be for something with contents that are not readily damageable. Preserving a structure for historic purposes is one example. There are also other possibilities such as removing part of the contents, relocating one of a group of structures, or modifying an existing structure to accommodate a new use. In each case the purpose is to remove damageable property from the hazard area, yet take advantage of opportunities for using the existing property in ways which are compatible with the hazard.

<u>Physical Feasibility</u>. While the experience and equipment exist for moving many different types of structures, there is a practical limit on the size and type of structure that is economically feasible to move to reduce flood losses. Even the most readily relocatable structures are costly to remove.

One or two-story residential and light commercial structures of wood frame on raised foundations or basements are usually easy to move because of the structure weight and access to the first floor joists. Structures of brick, concrete or masonry can also be moved; however, additional precautions must be taken to prevent excessive cracking. Most commercial/industrial buildings are not feasible to move because of their



Raise Furnace, Water Heater, Washer,
Dryer to First Floor



Raise and Relocate Merchandise and Equipment,
Anchor Floatable Items.

Rearranging or Protecting Existing Property

FIGURE E-4

size and type of construction. Rather than relocate the structure, it is usually more practical to remove the contents and find a new use for it. Similar action is sometimes taken when the damage potential to contents is high, as with valuable merchandise or machinery. In such cases, if the contents cannot be protected in some other way they are often relocated out of the flood hazard area altogether.

The advantages of removing existing contents from a flood hazard area are listed below:

Advantages

. Flood damage to the existing contents is eliminated. If the structure is demolished potential structural damage is eliminated.

Disadvantages

. Damage to the structure and site remain if the structure is reused.

. Costs to remove contents and demolish the structure are high compared to other measures.

The advantages and disadvantages of removing existing structure and contents from a flood hazard area are listed below:

Advantages

. Flood damage is eliminated because there is no residual damage.

. Removal allows land use adjustments that may be beneficial to the community.

. Improved hydraulic performance for passing flood flows.

. Maintenance of flood plain land may be reduced.

Disadvantages

. Compared with other measures for existing structures, removal is costly.

. Advantages associated with being at the flood plain site are lost.

. The vacated site requires continued maintenance with associated costs.

e. <u>Summary of Floodproofing Measures</u>

Floodproofing, as part of the entire spectrum of nonstructural flood damage reduction measures, has important value when considered as part of a broader program for comprehensive flood plain management. Continued occupance of developed floodplain sites, and even new development of such sites, may become necessary in some low-lying places, especially in certain urban areas where a shortage of land may offer no realistic alternative. The nonstructural measures for flood damage reduction have an important role alongside traditional structural measures usually associated with major flood control projects.

However, the foregoing general conclusion should not be misunderstood or misinterpreted. Nonstructural measures, like structural measures, have their particular applications and limitations. Each measure must be evaluated for its specific application in the reduction of flood damages and only then can it be decided that the particular measure is feasible, physically and economically.

Some measures could be used exclusively for existing development, others for future; some for residential structures, and others for commercial/industrial buildings; some at locations of frequent flooding, others where it is less frequent.

Lastly, floodproofing and the nonstructural approach to flood loss reduction are not cures for all flood problems. They can increase interest in flood damage reduction programs by heightening public awareness of the flood risk.

FLOOD FORECAST, WARNING AND EVACUATION

Flood forecast, warning and evacuation is a strategy to reduce flood losses by charting out a plan of action to respond to a flood threat. The strategy includes:

- A system for early recognition and evaluation of potential floods.
- Procedures for issuance and dissemination of a flood warning.
- Arrangements for temporary evacuation of people and property.
- Provisions for installation of temporary protective measures.
- A means to maintain vital services.
- A plan for postflood reoccupation and economic recovery of the flooded area.

Flood warning is the critical link between forecast and response. An effective warning process will communicate the current and projected flood threat, reach all persons affected, account for the activities of the community at the time of the threat (day, night, weekday, weekend) and motivate persons to action. The decision to warn must be made by responsible agencies and officials in a competent manner to maintain credibility of future warnings.

An effective warning needs to be followed by an effective response. This means prompt and orderly evacuation of people and property. Actions which can facilitate this include:

. Establish of rescue, medical and fire squads.

. Identification of rescue and emergency equipment that can be utilized during a flood.

. Identification of priorities for evacuation.

. Surveillance of evacuation to insure safety and protect property.

In addition to evacuation, property can be protected by various measures, temporary flood proofing of structures, use of pumps and flood fighting. For instance flood fighting includes such actions as raising the level of existing protection; closing highways, streets and railroads; preventing backwater in sewers; and protecting against erosion. All of these actions contribute to the overall goal of reducing flood loss.

In addition, a forecast, warning and evacuation strategy will include telephone, energy (gas and electric), sewage, water, traffic control and hospitals as well as police and fire services. Postflood reoccupation and recovery includes:

. Reestablishment of conditions that will not endanger public health: disease and insect control, safe drinking water, safe sewage disposal, medical supplies.

. Return of other vital services.

. Removal of sediment, debris, flood fighting equipment and materials.

. Repair of damaged structures.

. Establishment of disaster assistance centers for financial and other assistance.

Factors that determine the physical feasibility of forecast, warning and evacuation measures are somewhat different from those which determine the physical feasibility of many other nonstructural measures, whose feasibility is directly related to the type of structure and depth of flooding. Forecast, warning and evacuation feasibility is more dependent upon hydrologic, social and instritutional factors. The selection and feasibility of forecasting capability depends upon the size of the drainage area, whether the river is a main stem or tributary, travel time, and other hydrologic factors that influence the reliability of forecasts. Small watersheds generally have short response times, making it especially difficult for warnings to be helpful. The feasibility of warning systems also depends upon social factors. One system may be appropriate for one community, but not for another because an infrastructure of community and institutional arrangements is necessary to effectively use hydrologic information. The degree to which this infrastructure is created influences the effectiveness of different warning and evacuation measures.

Advantages

. Preparedness planning is almost always economically feasible and desireable. Something can usually be done even in areas where other flood loss reduction measures are implemented.

. A significant saving of lives may result in flash flood or water related structural failure situations.

. Accurate forecasts and warnings may permit sufficient time to implement temporary protective measures to significantly reduce flood damage.

Disadvantages

. The effectiveness of the warning system and response of the community cannot be accurately predetermined, consequently neither can potential flood damage reduction.

. Requires a continuous awareness and information program, maintenance of equipment, etc.

. Effectiveness of preparedness plans tends to diminish with increasing time between floods.

FLOODPLAIN REGULATIONS

Through proper land use regulation, floodplains can be managed to insure that their use is compatible with the severity of a flood hazard. Several means of regulation are available, including zoning ordinances, subdivision regulations, and building and housing codes. Their purpose is to reduce losses by controlling the future use and changing the existing use of floodplain lands.

Some regulations covering the use of the floodplains are already in effect in the communities within the study area. Regulations may be relatively prohibitive or may allow construction, provided the new structures are floodproofed and/or elevated above a designated flood elevation.

Physical Feasibility. Zoning ordinances, subdivision regulations, and building and housing codes are generally feasible for any floodplain land, whether the land is occupied by residential, commercial or industrial structures, or by nonstructures such as golf courses and playgrounds. While there are no general limitations, a regulatory program is developed and administered for a specific piece of land in a specific community and State; thus, when developing such regulations at the local level some very real restrictions may develop.

Regulations must be flexible and fair. Procedures for amendments and variances are necessary and can be provided by establishing criteria for special use permits. Also, regulations must be designed to prevent public harm rather than serve public benefits.

Advantages

. An effective means of bringing about the proper use of floodplain lands. Economic, environmental, and social values can be integrated with the recognized flood hazard.

. Helps to keep flood damage from increasing. By addressing nonconforming uses they can be helpful in achieving the necessary land use adjustments to mitigate existing flood problems.

. Can be effective over time on existing improper development or additions and modifications to existing property.

Disadvantages

. Not effective in reducing flood damage to existing structures.

. Subject to variance or amendment by local governmental bodies which can reduce effectiveness considerably.

. Tend to treat all floodplain property equally when in fact various economic factors may make one type of development more appropriate for one portion of the floodplain and another type more appropriate elsewhere.

FLOOD INSURANCE

Flood insurance is not really a flood damage prevention measure as it doesn't reduce damages, rather it provides protection from financial loss suffered during a flood. The National Flood Insurance Program was created by Congress in an attempt to reduce, through more careful planning, the annual flood losses and to make flood insurance protection available to property owners. Prior to this program, the response to flood disasters was limited to the building of flood control works and providing disaster relief to flood victims. Insurance companies would not sell flood coverage to property owners, and new construction often overlooked new flood protection techniques. The insurance program, however, did not come about overnight; it took several attempts and 17 years before the bill was approved and put into effect.

Flood insurance compensates purchasers for losses to the dwelling or business they own and to the contents of these buildings. Flood insurance is an option for all owners of existing buildings in a community approved for the sale of flood insurance, yet it is compulsory for all buyers of existing or new buildings in the Federal Emergency Management Agency (FEMA) designated 100-year floodplain where Federally insured mortgages or mortgages through Federally connected banks are involved.

Qualifying for the National Flood Insurance Program involves a community in two separate phases -- the emergency phase and the regular phase. The emergency phase limits the amount of insurance available to local property owners. In this phase, FEMA provides the community with a Flood Hazard Boundary Map that outlines the flood-prone areas within the community. Owners of all structures, regardless of their flood risk, are charged subsidized rates during this phase of the program.

In order to quality for the Emergency Program, a community must adopt preliminary floodplain management measures including building permits for all proposed construction or other development in the community, which must be reviewed to assure that sites are reasonably free from flooding. The community must also require that all structures in flood-prone areas be properly anchored and made of materials that will minimize flood damage, new subdivisions must have adequate drainage, and new or replacement utility systems must be located and designed to prevent flood loss.

The full amount of flood insurance is available under the regular phase of the program. The amounts charged for insurance of new construction vary in accordance with the structures. Flood plain management efforts of the community become more comprehensive and new buildings must be elevated or floodproofed above certain flood levels. The floodproofing levels are shown on a Flood Insurance Rate Map which is derived from a detailed on-site engineering survey in the community. This map also shows flood elevations and outlines risk zones for insurance purposes.

When the Flood Insurance Rate Map is completed, the community may qualify for the Regular Program by adopting more comprehensive floodplain management measures. Along with the measures adopted for the emergency program, the community must also require that all new construction or any substantial improvements to existing structures be elevated or floodproofed to the level of the base flood. All of the communities in the study area are in the Regular Program.

Advantages

- Inexpensive to the insured at the subsidized rate.
- Available to persons in many communities.
- Indemnification is for any flood up to the limits of the policy.

Disadvantages

. Only available to persons in communities eligible to participate in the Flood Insurance Program.

. Indemnification is limited both in magnitude and in type of damage.

. A deductible provision for each loss makes it somewhat less attractive for low damage flooding.

. Damages are not reduced.

PUBLIC ACQUISITION OF FLOODPLAIN LAND

Public control over the floodplain may be obtained by purchasing the title or some lesser rights to it such as development rights, right of public access, or rights to use the land in some specified way.

Acquisition of the title is most suited for the undeveloped or sparsely developed land in most of the floodplain. Given the amount of land along the Connecticut coastline this approach has practical limitations. It is a very desirable means, however, of protecting and or providing public access to particularly sensitive or significant areas for environmental, wildlife protection, public open space and recreation or other purposes. Federal and State programs may be enlisted for grant and loan assistance to offset a portion of the cost of acquiring the land. With the amount of protection now available through local flood plain regulations, a program of public land acquisition is not deemed practical at this time.

The acquisition of other interests in land may be an effective instrument to insure that it remains in low intensity uses such as agriculture, tree farms, private camping areas and the like. The means of accomplishment is usually an easement granted or sold to the public agency. Ownership, use, access and occupancy may be retained by the owner, but use is restricted by the terms of the easement. In experiences with this form of land use control it has been found, in some cases, that the purchase of development rights may be almost as expensive as acquiring the full title because the owner's options have been reduced so much. Coupled with tax incentives, however, the technique has a great deal of promise as a floodplain management method.

Costs of acquisition in fee or easement depend upon the cost per acre and number of acres needed. Both items are highly variable and must be determined on a case-by-case basis. Per unit costs can vary considerably within a community, between communities and regionally. The number of acres needed depends upon the plan--it may require a few acres or thousands of acres.

Advantages

- Provides control of land and its use with fee title.

- Provides control of certain land uses with an easement, but without the burden of fee title.

Disadvantages

- Does not reduce existing damage.

- Requires land management and maintenance by the public owner.

Appendix F

Pertinent Correspondence

April 12, 1989

Planning Division
Impact Analysis Branch

Mr. Earle G. Shettleworth
Maine Historic Preservation Commission
55 Capitol Street
State House Station 65
Augusta, Maine 04335

Subject: Water Resources Reconnaissance Investigation: Penobscot River Basin

Dear Mr. Shettleworth:

The Army Corps of Engineers is preparing a reconnaissance report on the Penobscot River Basin in Penobscot County and Piscataquis County, Maine. This investigation is being conducted to study water resource problems, with particular attention to flooding aspects and possible solutions along the river in the following towns: Abbot, Guilford, Dover-Foxcroft, Milo, Howland, Passadumkeag, Milford, Oldtown, Orono, Bradley, Eddington, and Brewer (Figure 1). We are providing your office with this information as background in the event this project proceeds to a further stage of planning.

This study is focusing on specific areas in these communities which suffer the most serious flooding problems. These towns contain several historic commercial, residential and industrial structures which are prone to flood damage and are being evaluated in this study (photographs enclosed). Saint Anne's Church in Oldtown and the James Sullivan Wiley House in Dover-Foxcroft are listed on the National Register of Historic Places.

This is a preliminary investigation. If this project proceeds to a further stage of planning, only non-structural alternatives such as house raising and floodproofing closures for windows and doors will be proposed. Therefore, additional background research will be directed mainly towards the analysis of historic structures within the proposed project area. This will involve identification of significant historic sites, the effect the proposed protection projects will have on these structures and the development of possible mitigation plans. We have initiated discussions with the Advisory Council on Historic Preservation (ACHP) and other agencies about floodproofing historic structures, and evaluating the effect on National Register properties.

A member of my archaeological staff has prepared, for the reconnaissance report, a brief historic background and historic resources summary. Dr. James Petersen and Dr. Thomas Baker of the University of Maine at Farmington Archaeology Research Center, under contract with the Corps, have prepared a management summary of the prehistoric cultural resources for inclusion in our reconnaissance study. Both summaries are enclosed with this informational letter.

If the project proceeds to a further stage in the planning process, then we will request your formal comments and recommendations in compliance with Section 106 of the National Historic Preservation Act of 1966, as amended. If you have any questions, please call Kate Atwood of my staff, at (617)-647-8796.

Sincerely,

Joseph L. Ignazio
Chief, Planning Division

Enclosure

John R. McKernan, Jr.
Governor

Nathaniel H. Bowditch
Commissioner

Department
of
ECONOMIC AND COMMUNITY DEVELOPMENT

March 20, 1989

Mr. Joseph L. Ignazio
Department of the Army
424 Trapelo Road
Waltham, MA 02254

RE: Penobscot River Basin

Dear Mr. Ignazio,

Recently, the Natural Heritage Program was transferred from The Nature Conservancy to the Office of Comprehensive Planning in DECD as part of an agreement to coordinate information management between the Critical Areas Program and the Heritage database. Our goal is a prompt reply to requests about rare and endangered species, natural communities and registered Critical Areas. As such, your request to the Critical Areas Program was forwarded to us for initial processing.

I have checked the Natural Heritage data base in response to your request of 6 February 1989 regarding rare natural features in the vicinity of the Penobscot River in Penobscot and Piscataquis Counties,in Maine.

The data base includes animals, plants, and natural communities that are endangered, threatened, or considered rare in Maine. Nine occurrences have been reported for the location mentioned above (see list on next page). For more detailed information about the Critical Areas appearing on the enclosed list, please contact Critical Areas Program, State Planning Office, State House Station 38, Augusta, Maine 04333.

In addition to the above, we have on file historical records for fourteen species. The information on the historical records is recorded from the museum labels of the species which were collected. The location information is not specific, but indicates that these species could have been collected from the area you are reviewing. These records have not been confirmed by Natural Heritage Program staff and may exist within the project boundary.

130 219 Capitol St.
State House Station ~~39~~, Augusta, Maine 04333 — *Offices Located at* ~~*193 State Street*~~
Telephone (207) 289-~~2656~~ 6800

The enclosed list includes the names of the species and their state status. This list can serve as a guideline for field work conducted for this project review. Flood control in the project area could destroy one or more of these occurrences.

The Natural Heritage Program has compiled data on Maine's rare, endangered, or otherwise significant plant and animal species, plant communities, and geological features. While this information is available for preparation and review of environmental assessments, it is not a substitute for on-site surveys. The quantity and quality of data collected by the Natural Heritage Program are dependent on the research and observations of many individuals and organizations. In most cases, information on natural features is not the result of comprehensive field surveys. For this reason, the Maine Natural Heritage Program cannot provide a definitive statement on the presence or absence of unusual natural features in any part of Maine.

The Natural Heritage Program welcomes coordination with individuals or organizations proposing environmental alteration, and/or conducting environmental assessments; however, the information, or lack thereof, provided by the Natural Heritage Program should never be regarded as a complete statement on the elements of natural diversity being considered. If data provided by the Natural Heritage Program are to be published in any form, the Program should be informed at the outset and credited as the source.

Please take note that the Maine Department of Inland Fisheries and Wildlife has statutory authority for birds, mammals, reptiles, amphibians and fishes. This agency should be notified to insure a complete review of the project area. Their address is State House Station 17, Augusta, Maine, 04333.

Thank you for using the Natural Heritage Program as part of your environmental review procedure. Please do not hesitate to contact me if you have further questions about the Natural Heritage Program. In the future if you have requests about locations of rare and endangered species or registered Critical Areas contact us directly.

Sincerely,

Francie C. Tolan

Francie C. Tolan
Data Manager
Natural Heritage Program

Enclosures
cc: Trish DeHond, CAP

Extant Occurrences of Species and Registered Critical Areas

1. Carex hassei
   Spiranthes lucida

2. Erigeron hyssopifolius

3. Lampsilis cariosa

4. Carex oronensis
   Houstonia longifolia
   Northern New England High Energy Riverbank

5. Carex oronensis

6. Viola novae-angliae
   Critical Area #599, Penobscot River Rare Plant Station

Town Records Where Exact Species Location is not Known

Guilford	Eleocharis pauciflora
	Trisetum melicoides
Dover-Foxcroft	Platanthera flava
	Trisetum melicoides
	Scutellaria parvula
	Primula mistassinica
Old Town	Viola novae-angliae
	Carex adusta
Orono	Carex oronensis
	Ceanothus americanus
	Houstonia longifolia
Bangor	Carex oronensis
	Mimulus ringens var colpophilus
	Sagittaria montevidensis

JOHN R. MCKERNAN, JR.
GOVERNOR

STATE OF MAINE
OFFICE OF THE GOVERNOR
AUGUSTA, MAINE
04333

March 9, 1988

Colonel Thomas A. Rhen
Department of the Army
424 Trapelo Road
Waltham, MA 02254-9149

Dear Colonel Rhen:

Thank you for your letter requesting a state coordinator for activities of the New England Division of the Corps of Engineers.

I understand that Ms. Katrina Van Dusen of the Maine State Planning Office has been serving successfully as the point of contact for Corps activities in Maine. Please let this letter serve as formal notice of Maine's actions.

We look forward to continued close coordination with the Corps through enhanced communication.

Sincerely,

John R. McKernan, Jr.
Governor

JRM/lab

cc: Richard H. Silkman, Director
State Planning Office

Katrina Van Dusen, Director
State Planning Office

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION I

J.F. KENNEDY FEDERAL BUILDING, BOSTON, MASSACHUSETTS 02203-2211

March 3, 1989

Mr. Joseph L. Ignazio, Chief
Planning Division
Impact Analysis Branch
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254

Dear Mr. Ignazio:

We have reviewed the preliminary information for the reconnaissance study of the Penobscot River Basin in Maine to investigate flooding problems and possible flood control solutions. Two types of flood control measures are being considered for twelve communites within this river basin. Structural measures include dikes and walls, channel modifications and modifications to existing dams. Non-structural measures include floodproofing buildings, flood insurance, and relocation of flood prone structures.

According to the January 30, 1989 planning aid letter to you from Gordon Beckett of the U.S. Fish and Wildlife Service, the Penobscot River Basin and many of its tributaries, associated ponds and wetlands provide excellent habitat for a variety of fish and wildlife. All of the structural alternatives being considered would adversely impact these resources. Without more detailed information, it is impossible to accurately evaluate the extent of these impacts.

However, due to the value of the resources that would be impacted by these alternatives, we recommend serious consideration of non-structural alternatives. These types of measures generally have fewer adverse environmental impacts than structural methods and may be the only way to avoid adversely impacting valuable aquatic resources while still providing flood protection.

Finally, future studies should include information regarding the need and costs for the project as this information is necessary to decide whether a project should go forth despite its adverse impacts.

We will provide more detailed comments upon receipt of additional information about the project. In the meantime, if you have any questions regarding this letter, please contact Pamela Shields of my staff at 565-4429.

Sincerely,

Douglas A. Thompson, Chief
Wetland Protection Section

cc: Ron Manfredonia, Chief, WQB
Mike Tehan, FWS, Concord, NH

February 6, 1989

Planning Division
Impact Analysis Branch

Ms. Patricia DeHond
Critical Areas Program
Maine State Planning Office
184 State Street
State House, Station 38
Augusta, Maine 04333

Dear Ms. DeHond:

The Corps of Engineers is conducting a reconnaissance study to investigate flooding problems and possible flood control solutions in a number of towns located in the Penobscot River Basin. The purpose of this letter is to request a list of any rare, threatened, or endangered plant or animal species occurring in the general vicinity of the project areas.

A list of the towns under study is presented below. Towns in which dikes or walls situated in (or near) the riparian zone may be recommended are denoted by an asterisk. In other towns only nonstructural solutions are likely to be proposed. Location maps are enclosed to aid you in your work.

Penobscot County

- Bradley*
- Brewer
- Eddington
- Howland*
- Milford
- Old Town*
- Orono*
- Passadumkeag*

Piscataquis County

- Abbot
- Dover-Foxcroft*
- Guilford*
- Milo*

Other potential flood control measures under consideration are channel improvements upstream of the Guilford Dam (Guilford) and the placement of flood control gates at the discharge point of a pond on Indian Island (Old Town).

If you require any further information about this project or the effected areas please contact Mr. Michael Penko of the Impact Analysis Branch at (617) 647-8139.

Sincerely,

Joseph L. Ignazio
Chief, Planning Division

Enclosure

United States Department of the Interior

FISH AND WILDLIFE SERVICE
400 RALPH PILL MARKETPLACE
22 BRIDGE STREET
CONCORD, NEW HAMPSHIRE 03301-4901

January 30, 1989

Mr. Joseph Ignazio, Chief
Planning Division
New England Division
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254

Dear Mr. Ignazio:

This planning aid letter is intended to provide a preliminary assessment of potential fish and wildlife impacts from several alternatives evaluated by the New England Division for the flood protection reconnaissance study of the Penobscot River Basin within Penobscot and Piscataquis Counties, Maine. It has been prepared under the authority of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.).

The reconnaissance investigation focuses on twelve communities with flood damages within the Piscataquis and mainstem Penobscot River Basins. These are: Abbot, Guilford, Dover-Foxcroft, Milo, Howland, Passadumkeag, Milford, Old Town, Bradley, Orono, Eddington, and Brewer. Two types of flood control measures are being examined for the reconnaissance study: structural measures to reduce flooding and non-structural measures to reduce or mitigate flood damages. Structural measures to reduce flooding at critical damage areas include levees and walls, channel deepening/widening, and modifications to existing dams. It is our understanding that the potential for structural measures is being evaluated at eight of the twelve flood damage areas: Guilford, Dover-Foxcroft, Milo, Howland, Passadumkeag, Old Town, Bradley, and Orono. This planning aid letter focuses on the fish and wildlife resources and potential impacts of structural measures at these eight sites.

Non-structural flood control measures such as floodproofing buildings, flood insurance, and relocation of flood-prone structures (depending on the site where the structures are relocated) usually do not cause significant adverse impacts to fish and wildlife resources. Non-structural flood control measures are preferred by the Fish and Wildlife Service due to their low level intensity of adverse impacts. Those sites where only non-structural measures are being considered have not been addressed in this report.

EXISTING RESOURCE VALUES

The Penobscot River Basin, located in central Maine, occupies approximately one quarter of the state's land area. The Basin lies between the Saint John River Basin to the north, the St. Croix River basin to the east, the Kennebec River basin to the west and coastal basins to the south. The mainstem Penobscot River begins at Medway with the juncture of the East and West Branches, which drain a total of 3300 square miles. The River then flows 74 miles south to tidal influence at Bangor, and another 31 miles to Penobscot Bay. There are three main tributaries to the mainstem Penobscot: the Mattawamkeag, the Piscataquis, and the Passadumkeag Rivers. The Basin is generally forested, with rolling hills rising above wide flat valleys. The northern portions of the Basin comprise one of the largest wilderness areas remaining in the eastern United States. Elevation averages 1000 to 1500 feet, with the highest summit being 5267-foot Mt. Katahdin. There are numerous lakes and ponds, many of which are greater than 1000 acres.

Flows in the Penobscot River Basin have been moderated by storage reservoirs, resulting in decreased peak flows and increased summer low flows. The majority of existing water storage in the basin is in the East and West Branches of the Penobscot and in the Piscataquis River Basin. There is approximately 1.3 million acre-feet of storage in the West Branch Penobscot Basin regulated by dams operated by the Great Northern Paper Company. The Piscataquis Basin has over 100,000 acre-feet of storage for use by Bangor Hydro-Electric at downstream power projects.

Portions of the study area fall into river segments that have received special resource recognition in the Maine Rivers Inventory. Two designated segments lie within the reconnaissance study area-- the mainstem Penobscot and the mainstem Piscataquis.

The mainstem Penobscot River from Veazie Dam to Sandy Point at Penobscot Bay has been designated a category "A" river, denoting outstanding composite natural and recreational resource values, with significance extending beyond the state. Resource values identified in the inventory include:

Critical/Ecologic: This river segment is one of the three most important bald eagle wintering areas in the state. Depending on conditions, the reach may support the highest density of wintering birds in Maine. The river corridor provides known or historic habitat for a number of rare or threatened plants, including species with national, regional, and state significance.

Anadromous Fish: The Penobscot Atlantic salmon run is being restored and is reported to be the nation's largest Atlantic salmon fishery. The river is the state's highest priority salmon fishery and has received high expenditures for stocking and fishways. Bangor and Veazie Dam pools are reportedly the most productive and intensely fished in the eastern United States. Production potential for rainbow smelt is high and the reach supports a popular spring smelt fishery. Anadromous fish species diversity is the second highest in the state.

Significant recreational boating and historic resources were also noted.

The entire Piscataquis River, from Howland to the West Branch has been designated a category "B" river in the Inventory. Eight categories of resource values with statewide significance have been identified. These include:

Geologic/Hydrologic: Regionally significant gorges and waterfalls are located on the East Branch Piscataquis River.

Critical/Ecologic The river crosses through several major ecologic zones, including northern hardwoods, spruce-fir, transitional hardwoods, and rural river valley. There are regionally significant headwater bogs in the vicinity of Little Squaw Mountain. Ledges and rocky shores between Daggett Brook and Guilford are historic habitat for the nationally significant Robinson's Hawkweed. Six other plants that are rare in the region are also found in this segment.

Anadromous Fish: The entire Piscataquis River system provides spawning habitat for Atlantic salmon. The watershed has significant potential for increased salmon production. Fishways have been constructed by the Atlantic Sea Run Salmon Commission at dams in Guilford, Dover-Foxcroft, and Howland as part of the restoration program.

Inland Fisheries: The entire river is recognized as a quality native brook trout fishery with good access for angling.

Boating: Recreational boating use is high on the mainstem Piscataquis. The reach between Howland and Guilford is popular for canoe touring.

Wildlife Resources

Wildlife habitat at all of the communities where structural solutions are being considered is generally limited to relatively narrow bands of riparian and wetland vegetation along the river's edge. The primary habitat values of these riparian areas include: nesting and feeding habitat for migratory and resident birds; cover and movement corridors for small mammals, particularly furbearers; and food production (i.e. terrestrial insects), shade, and cover for fish, particularly life stages that utilize shallow nearshore habitats.

Common mammals that could be expected to utilize project areas include: beaver, muskrat, mink, snowshoe hare, raccoon, striped skunk, porcupine, eastern chipmunk, woodchuck, gray and red squirrel, red fox, and white-tailed deer. Small mammals such as shrews, mice and voles are likely common residents at most of the sites. Other mammals found in the Penobscot River Basin include black bear, moose, bobcat, otter, fisher and marten.

The project sites provide breeding, foraging, and wintering habitat for a variety of bird species. Waterfowl, shorebirds, passerines, wading birds, and raptors are among the bird groups that would use the area. Breeding waterfowl species include black duck, ring-necked duck and wood duck. Ruffed grouse and woodcock are the primary upland game bird inhabitants. Birds observed during our November 16, 1988, site visit include: great blue heron, mallard, common merganser, double-crested cormorant, herring gull, belted kingfisher, American crow, black-capped chickadee, American robin, song sparrow and winter wren.

Our August 22, 1988, letter to the Planning Division provided endangered species information for a number of reconnaissance studies. As noted in that letter, we have determined that a federally listed species, the bald eagle, occurs in the project vicinity. The Penobscot River Basin is one of the three most important bald eagle wintering areas in the state. The Basin is also important to nesting eagles. There are several nests along the mainstem and tributaries, and the number of nesting sites has been increasing. Specific use along the river includes foraging, diurnal perching, nocturnal roosting, and nesting. Due to the occurrence of eagle nests along the Penobscot and tributaries, year round eagle use can be expected in the vicinity of the project sites. Wintering birds tend to concentrate around open water areas, particularly below dams. Birds have been observed in the vicinity of Howland and Great Works dams during the December-March wintering period. Nesting birds are known to forage along the lower Passadumkeag River, and roost on islands at the river mouth.

In accordance with Section 7 of the Endangered Species Act of 1973, as amended, (16 U.S.C 1561, et seq.), the Corps of Engineers is required to assure that their actions have taken into consideration impacts to Federally listed or proposed threatened or endangered species for all Federally funded, constructed, permitted, or licensed projects. The Corps responsibility to address impacts to threatened and endangered species associated with Federal projects is described in Sections 7(a) and (c) of the Endangered Species Act. More detailed coordination on endangered species issues must occur if the project proceeds to the feasibility stage. For information on state listed species, you should contact Steve Timpano, Maine Department of Inland Fisheries and Wildlife, 284 State Street, Augusta, 207-289-5258.

Fishery Resources

The Penobscot River is probably best known for its outstanding diversity of anadromous fish resources. Among these are Atlantic salmon, American shad, Atlantic sturgeon, alewife, blueback herring, rainbow smelt, and striped bass. American eel and sea lamprey also occur in the Penobscot River. Historic Penobscot Atlantic salmon runs were famous nationwide and numbered between 45,000 and 75,000 adults prior to 1800. Habitat degradation associated with the timber industry, industrial pollution, and dam construction all but eliminated this resource by the 1950's. In the 1960's, the Penobscot River was chosen to serve as a model for the restoration of a highly developed river system. As a result of an intensive stocking program combined with natural production, spawning runs of more than 900 fish have returned every year since 1977. There is an intensive sport fishery for Atlantic salmon in the mainstem below Veazie Dam. The Bangor Pool vicinity is considered some of the finest Atlantic salmon angling in the region.

Historically, there were also large runs of American shad and alewives in the Penobscot River. They too were drastically reduced by habitat degradation. The river currently supports residual runs of shad and alewives. Actual numbers are unknown, but have been estimated at around 1.5 million shad and 14.5 million alewives. Current plans call for passive restoration of these species, i.e natural production with little or no stocking.

Fish passage facilities have been constructed at the mainstem dams on the Penobscot and Piscataquis Rivers. As a result, Atlantic salmon, American shad, and alewives have access to all of the study reaches under consideration for this reconnaissance study.

The Penobscot River also supports important resident inland fishery resources. Cold water fisheries, for the most part seasonal, include native brook trout and landlocked salmon. The Maine Department of Inland Fish and Wildlife is currently restoring brook trout populations in the Piscataquis River with annual fish plants in the Guilford to Dover-Foxcroft reach. Warm water fisheries are found at all of the study sites and are comprised primarily of smallmouth bass, chain pickerel, and perch (white and yellow). The Passadumkeag River supports an active fishery for American eel. The eel fishing weir is located near the mouth of the river, adjacent to the project site. Other fish species expected to occur in project-affected reaches include: red-breasted sunfish, longnose and white sucker, fallfish, blacknose dace, creek chub, common shiner, and brown bullhead.

Water quality in the Basin has historically limited fishery resources because of pollution from untreated industrial and municipal discharges. Cleanup efforts begun during the 1970's are continuing today, and water quality in the Basin has been significantly improved. At the present time, study sites along the mainstem Penobscot River fall within a river segment designated as class "C" waters by the state of Maine. The Piscataquis River from Guilford to the confluence with the Pleasant River is also designated class "C". From the confluence with the Pleasant River downstream to Howland, the Piscataquis is designated class "B". The Piscataquis River below Guilford has historically experienced serious violations of water quality standards due to untreated wastewater discharges. A secondary treatment plant is currently being brought on line to treat both municipal and industrial effluent and water quality should no longer be a problem in this reach. All of the other river segments currently meet established water quality standards. Although not serious enough to violate water quality standards, the mainstem Penobscot River below Veazie experiences periodic bacterial pollution from untreated discharges and combined sewer overflows. A number of local treatment plant projects are planned or underway, and bacterial pollution should become less problematic as local treatment facilities are brought on line.

Study Site Descriptions

Guilford

Three sites are being considered for structural flood control measures in Guilford—levees or walls at sites upstream and downstream of the Guilford Dam, and possible channel modifications immediately above the dam in the impoundment area. At the upstream site, there is a 100- to 250-foot wide shrub-scrub wetland that extends along the river for the full length of the study site, approximately 1500 feet. There are a wide variety of plant species here, including red-osier dogwood, gray birch, speckled alder, red maple, willow, spirea, elderberry, raspberry, clematis, reed canary grass, ash, big-tooth aspen, goldenrod, sedge spp., and grasses. There is good overhanging vegetative cover along the river. Pondweed was observed in the shallows along the river's edge. A band of riparian/wetland vegetation had recently been removed and replaced with grass, apparently as part of the new housing development adjacent to the site.

The river banks in the middle study reach support residential, commercial, and industrial development and offer little habitat value. Vegetation is generally limited to sparse tree and grass cover with species such as white pine, elm, white birch, and ash. There are several small patches of shrub-scrub wetland along the rivers edge.

The downstream site begins at River Street below the Guilford Dam, extends east to the mouth of Schoolhouse Brook, and includes the lower 750 feet of the west bank of Schoolhouse Brook. The reach along River Road was formerly the site of 10-12 waterfront homes that were destroyed in the 1987 flood. The site is sparsely vegetated with red oak, red maple, white pine, elm, grasses and Japanese knotweed (Polygonum sp). The river banks are steep and lack a well developed riparian or wetland edge. The area adjacent to Schoolhouse Brook is wetland and supports dense cover of alder, red-osier dogwood, spirea, and grasses. High water marks were visible to a height of seven feet on the trees here.

Dover-Foxcroft

There are two potential levee/wall sites upstream of the Dover-Foxcroft Dam; one adjacent to the Moosehead furniture factory on the north bank and another at the sharp bend along the south bank, across from the furniture factory. The north site is extensively disturbed from industrial development and has little habitat value. Much of the east half of this site has been previously riprapped and is sparsely vegetated with clover, burdock, mullein, nightshade, wild carrot, milkweed, and red maple. There is an earth and rock berm along the western half of the site. A band of box elder and elm trees between the berm and the river extends about 300 feet upstream.

The south bank site is characterized by a small stand of cattails, about 0.5 acres in size. This site also supports Japanese knotweed, burdock, asters and elderberry, however, the vegetation had been recently cut. The adjacent uplands are extensively developed and portions of the river bank are riprapped. Five mallards were observed along the shoreline here.

Milo

The potential levee site in Milo is along the south bank of the Sebec River, extending about 1500 feet upstream from the Milo Dam. The study site is bisected by a railroad bridge. There are several commercial and residential buildings at the eastern part of the site, with a narrow band of riparian vegetation, e.g. willow, red-osier dogwood, and elm. Waterward of the riparian vegetation is a six- to eight-foot-wide band of emergent wetland comprised of cattail and sedge. Upstream of the railroad bridge are several acres of emergent/shrub-scrub wetlands with sign of beaver activity (inactive lodge and cuttings). This wetland is predominately sedges, rush (Juncus sp.), and grasses, with scattered spirea, willow, red maple, and alder. There is a small stand of cattails adjacent to the bridge.

Howland

Possible levee sites in Howland would extend upstream of the Howland Dam on both sides of the river. The study site on the north side is approximately 2000 feet long, while the site on the south side extends about 1500 feet upstream from the dam. Both banks support residential development. River Road runs along the south bank and there is limited riparian or wetland fringe. Vegetation on the steep bank here is limited to several large white pine trees and sparse cover of white birch, red maple, and alder. There is a narrow fringe of riparian and wetland vegetation along the north bank, along the backyards of the houses there. Vegetation is mostly sedge, soft rush, elderberry, reed canary grass, raspberry, cinquefoil, and buttercup. Forested wetlands are found at the upstream end of the study site, at the mouth of a small drainage outlet. Among the species observed there are: red maple, ash, gray and white birch, hazelnut, red-osier dogwood, black cherry, aspen, elderberry, alder, and sensitive fern. Sign of beaver activity and flood scouring were observed here.

Another potential structural measure would be modification of the Howland Dam to reduce upstream flooding during peak flow conditions. This would be accomplished presumably by adding tainter gates or some similar structure. We cannot evaluate the potential for impacts to existing fish passage facilities until a specific dam modification proposal is available for our review.

Passadumkeag

The study site at the Passadumkeag River is at the confluence with the Penobscot River. Potential flood protection would extend along the north bank of the Passadumkeag for about 2500 feet and continue up the east bank of the Penobscot River for about 500 feet. A narrow band of riparian vegetation occurs between Route 2 and the river along the Penobscot River. The riparian zone becomes wider along the Passadumkeag River, particularly towards the east portion of the study area. Predominant vegetation includes aspen, gray birch, red maple, red oak, red-osier dogwood, willow, sensitive fern, burdock, goldenrod, grasses and sedges along the river. Alder and aspen were heavily cut by beaver, and we observed an active beaver lodge at the eastern end of the study site.

Old Town

There are two potential sites for structural solutions in Old Town. The northern site is on Indian Island and would possibly involve a water control structure at either the inlet and/or outlet to a small pond at the south end of the island to exclude flood waters. The pond is about an acre in size with a wetland fringe of soft rush, sweet gale, cattail, willow, nightshade, aster, and spirea. Waterfowl and herons have been observed there. The pond supports a local warm water fishery for species such as pickerel. The Penobscot Indian Nation has expressed an interest in possibly developing some type of fish culture project here.

The second site in Old Town is along the west bank of the Penobscot River between the Route 2 bridge and Great Works Dam and is about 3000 feet long. The Maine Central Railroad line runs parallel to the study site and lies directly adjacent to the river for the upper part of the study site. Along this reach, the river bank is riprapped and vegetated with a narrow band of locust, buckthorn, box elder, apple, alder, red maple, sycamore, cottonwood, nightshade, goldenrod, Japanese knotweed, verbena, and grasses. The middle portion of the study site includes a two to three acre stand of trees of the same composition. This area provides good overhanging cover and showed sign of beaver cutting and bank burrowing. The southern segment of the study site is open with grasses and forbs.

Bradley

The study site in Bradley extends from below the Great Works Dam on the east bank of the Penobscot River, 2000 feet downstream to the confluence with Otter Stream, and up the north bank of Otter Stream 2000 feet to the Bullen Street bridge. Despite its proximity to adjacent residential development, there is substantial wetland and riparian habitat at this study site, both along the Penobscot River and Otter Stream. For the most part, wetlands extend up to the backyards of the residences. Along Otter Creek, there are several acres of wetlands with sensitive fern, red-osier dogwood, cottonwood, box elder, red maple, elm, ash, hawthorne, apple, elderberry, soft rush, verbena, aster, raspberry, and grasses. Snags with cavities are present. Dense thickets of hawthorne and apples trees offer good food and cover for wildlife. Mallards were observed feeding among wetland vegetation in Otter Stream. That portion of the study site along the Penobscot River is primarily forested wetlands with a border of emergent vegetation. Species are similar to those along Otter Stream. Flood debris was visible ten feet up in the trees.

Orono

The study site in Orono is along the west bank of the side channel that flows around Ayers Island. The site extends approximately 1500 feet for the full length of South Penobscot Street, and is bisected by the old railroad spur to Basin Mills. Habitat is similar to the other mainstem sites, with a band of riparian and wetland vegetation sandwiched between the river and residential development. Vegetation is predominately silver and red maple, but also includes sugar maple, ash, viburnum, aspen, gray birch, willow, sensitive fern, nightshade, purple loosestrife, and reed canary grass. Beaver sign was observed throughout the site.

POTENTIAL PROJECT IMPACTS

The primary impacts of levee and floodwall construction would include: the direct physical loss of habitat from construction of the structures, construction-related impacts, such as wildlife disturbance and water quality degradation, and impacts to waterfront access and angling opportunities.

Construction of floodwalls and/or levees at most of the study sites could eliminate shallow-water rearing habitat, overhanging bank cover, riparian habitat, and/or wetlands. There is potential for wetland impacts at all of the communities where levees and/or floodwalls are being evaluated. Structures at Old Town and Dover-Foxcroft would likely encroach into the river channel due to inadequate setback space. Rare plant species could be affected at some sites. For information on rare and threatened plants, you should contact Mr. Hank Tyler, Maine Critical Areas Program, State Planning Office, State House Station 38, Augusta, 207-289-3261.

In addition to direct habitat losses from construction of the flood control structures, wildlife utilizing adjacent habitats could be displaced during disruptive construction activities. Depending on the season and length of the construction period, displacement may lead to direct mortality due to nest abandonment or dispersal-related losses (predation, competition, road kill, etc.). This disturbance factor would apply to all structural flood control measures. Although disturbance cannot be eliminated, mortality associated with nest failure can be reduced by scheduling all construction activities for the late summer and fall months.

Also of concern is the need to maintain public access for angling and boating where it currently exists, e.g. the boat launch at the mouth of the Passadumkeag River. Levees and floodwalls have the potential to block access to the river, depending on their location and design. Angling use and water access should be examined during the detailed project review phase.

Fish passage is a concern where structural control measures would affect dams with fishways or change stream hydraulics, e.g. at the mouth of tributaries. Fish passage conditions should be evaluated during the detailed project review phase if any proposed structural measures would affect dams (e.g. Howland Dam) or stream hydraulics.

Due to the degree of uncertainty regarding the actual design and siting of levees and floodwalls, we will need to review more specific project design information before we can fully evaluate the impact of any of these local protection projects. Before mitigation measures can be developed, more detailed habitat evaluations of affected areas for target species may be required.

Finally it should be noted that the Soil Conservation Service (SCS) is currently evaluating up to five sites in the upper Piscataquis River Basin for flood control reservoirs. We have been involved in their planning process since the early 1970's and have recommended that alternate means of flood control be pursued that would result in less environmental impact than dam construction, e.g. non-structural alternatives such as flood insurance, flood proofing, floodplain regulation, and land use changes. Future studies in the Penobscot Basin by the New England Division should address the relationship between flood control measures proposed by the Corps and those proposed by the SCS. Environmental studies should also address the potential for cumulative impacts to fish and wildlife resources in the Piscataquis Basin.

The use of nonstructural measures to prevent flood damage would, for the most part, not impact the fish and wildlife resources of the Penobscot River. The only possibility of habitat degradation from nonstructural measures would be if houses or other structures were relocated in wetlands or other wildlife habitat areas.

SUMMARY

All of the structural alternatives for flood control in the Penobscot River study area have the potential to impact wetlands and riparian habitat. Potential impacts associated with the construction of structural flood control measures would be the direct loss of shallow water habitat, wetlands, and riparian habitat; water quality degradation and wildlife disturbance/mortality associated with construction activities; impacts to water access for angling and boating; and impacts to fish passage where dams are modified.

Because of their habitat value and the difficulty in developing successful mitigation, we would recommend against the construction of levees and floodwalls within shallow water habitats, wetlands, or streamside riparian buffers. We recommend that nonstructural measures be investigated to accomplish flood control objectives where possible because they offer a solution that is essentially free of impacts to natural environmental features.

More detailed fish and wildlife impact analyses will be needed once specific local protection studies are started. Habitat evaluations for target species should be completed to determine site specific impacts of each local protection plan. Alternate alignments should be developed to minimize or avoid encroachment into wetlands and shallow water habitats. Potential fish passage impacts from dam modification should be evaluated. Additional coordination with state fish and wildlife management agencies will be needed to develop mitigative measures where impacts cannot be avoided. Site specific evaluations of bald eagle use and the potential for adverse impacts may be necessary to complete the biological assessment requirements under Section 7 of the Endangered Species Act.

Thank you for the opportunity to provide these planning aid comments. If you have any questions regarding this letter, please contact Michael Tehan of my staff at (603) 225-1411 or FTS 834-4411.

Sincerely yours,

Gordon E. Beckett

Gordon E. Beckett
Supervisor
New England Area

January 18, 1989

Planning Division
Impact Analysis Branch

Mr. Douglas Thompson
Chief, Wetlands Protection Section
U.S. Environmental Protection Agency-Region I
J.F.K. Federal Building
Boston, Massachusetts 02203-2211

Dear Mr. Thompson:

The Corps of Engineers is conducting a reconnaissance study of the Penobscot River Basin in Maine to investigate flooding problems and possible flood control solutions. The purpose of this letter is to request your input relative to the environmental effects and significance of potential flood control alternatives.

Although plan formulation studies are still underway, a preliminary list of communities and potential projects requiring evaluation is enclosed. Also under consideration are channel improvements upstream of the Guilford Dam (Guilford) and the placement of flood control gates at the discharge point of a pond on Indian Island (Old Town). Upstream reservoirs may require evaluation once the total amount of potential flood damage is known. At present however, no specific reservoir sites are under consideration.

If you require any further information about the proposed project, please contact Mr. Michael Penko of the Impact Analysis Branch at (617) 647-8139.

Sincerely,

Joseph L. Ignazio
Chief, Planning Division

Enclosure

Penobscot River Basin RECON Study

Town	Potential Projects		
	Dike or Wall	Floodproofing	Early Warning and Evacuation
Abbot		X	X
Bradley	X	X	X
Brewer		X	X
Dover-Foxcroft	X	X	X
Eddington		X	X
Guilford	X	X	X
Howland	X	X	X
Milford		X	X
Milo	X	X	X
Old Town	X	X	X
Orono	X	X	X
Passadumkeag	X	X	X

Planning Division
Basin Management Branch

OCT 4 1988

Mr. Albert Bishop
P. O. Box 1208
Bangor, ME 04401

Dear Mr. Bishop:

As discussed between you and Mr. David Baker of my staff by telephone on September 28, 1988, we would like to obtain record of the cost to the State of Maine for repair of road and bridge damage caused by the April 87 flood. The area of concern is from Abbot to Howland along the Piscataquis River, and Howland to Bucksport along the Penobscot River. This information will be used as part of a reconnaissance study of flooding in the Penobscot River Basin.

If you have any questions regarding the study please contact Mr. David Baker at (617) 647-8538.

Sincerely,

Joseph L. Ignazio
Chief, Planning Division

August 1, 1988

Planning Division
Impact Analysis Branch

Mr. Gordon E. Beckett
Supervisor
U.S. Department of the Interior
Fish and Wildlife Service
Ecological Services
22 Bridge Street
Ralph Pill Bldg., 4th Floor
Concord, New Hampshire 03301

Dear Mr. Beckett:

The New England Division has initiated reconnaissance investigations to develop flood damage reduction measures for flood prone areas in the Kennebec River, Androscoggin River and Penobscot River basins in Maine, and the Mascoma and Ashuelot River basins in New Hampshire. This office has also initiated an investigation of the coastal breach at Nauset Beach in Chatham, Massachusetts.

The purpose of this letter is to request a list of endangered or threatened species for the project areas, pursuant to Section 7(c) of the Endangered Species Act of 1973, as amended.

If you require any further information about these studies or the affected areas, please contact Ms. Susan Brown of the Impact Analysis Branch at (617) 647-8029.

Sincerely,

Joseph L. Ignazio
Chief, Planning Division

July 7, 1988

Planning Division
Basin Management Branch

Mr. Tom Marcotte
Maine Office of Economic and
Community Development
State House Station #130
Augusta, Maine 04333

Dear Mr. Marcotte:

The purpose of this letter is to confirm your telephone discussion of July 6, 1988 with Mr. Heidebrecht of my staff concerning a series of meetings that have been arranged regarding the Penobscot River Basin reconnaissance study. The date, time, primary contacts and location of these meetings are listed below:

July 11, 1988; 2:00 p.m.;	Joseph Bertolaccini U.S. Soil Conservation Service Orono, Maine
July 12, 1988; 9:30 a.m.;	Doug Morrill/Rex Grover Bangor Hydroelectric Co. Bangor, Maine
July 12, 1988; 1:30 p.m.;	Don Meagher/Betsy Bass Penobscot Valley Council of Governments Bangor, Maine
July 13, 1988; 9:30 a.m.;	Paul Pirlotte Great Northern Paper Co. Millinocket, Maine

The primary purposes of these meetings will be to discuss our recently initiated study, and to gather any available information concerning flooding in the Penobscot River Basin.

Thank you for your assistance in contacting the above agencies and companies and informing them that we would contact them to arrange for these meetings. Please contact me at (617) 647-8508 or Mr. Richard Heidebrecht, Project Manager, at (617) 647-8217, if you have any questions concerning these meetings.

Sincerely,

Joseph L. Ignazio
Chief, Planning Division

Planning Division
Basin Management Branch

MAR 26 1988

Honorable John R. McKernan, Jr.
Governor of the State of Maine
Office of the Governor
Augusta, Maine 04333

Dear Governor McKernan:

I want to thank you for your letter of March 9, 1988, that informed us that Ms. Katrina Van Dusen of the Office of State Planning will be your State's overall Coordinator for the planning and technical support activities of the New England Division of the Corps of Engineers. We will be keeping Ms. Van Dusen informed of all of our activities in Maine.

This year the New England Division is initiating reconnaissance investigations of the four major river basins in Maine that experienced heavy flood damages in the Spring of 1987. Reconnaissance investigations for the basins of the Kennebec, Saco and Penobscot Rivers were authorized by the May 5, 1987 resolution of the Senate's Committee on Environment and Public Works. The reconnaissance investigation of the Androscoggin River was authorized by the November 12, 1987 resolution of the Senate's Committee on Environment and Public Works. Working with the State, we will examine the broadest realm of water resources problems and needs to determine any Federal interest and your willingness to participate in feasibility studies.

These reconnaissance investigations are fully Federally funded and could lead to feasibility investigations that would be cost-shared by the State or its sub-divisions. We are required by regulation to complete each of these reconnaissance investigations with draft feasibility study cost sharing agreements (FCSA), where warranted, within twelve months of initiation of the investigation. Since the State would be a partner with the Federal Government in any feasibility investigations that would result from these reconnaissance investigations, we invite the Maine State government to participate in the investigations and the development of any FCSA agreements that would allow us to jointly produce an acceptable product within this rigid 12 month timeframe.

The project managers that I've assigned to the reconnaissance studies are:

Project Manager	Phone	River Basin
Michael Keegan	(617)647-8241	Kennebec River Saco River
Grant Kelly	(617)647-8551	Androscoggin River
Richard Heidebrecht	(617)647-8217	Penobscot River

I have instructed the study managers to keep Ms. Van Dusen informed on the reconnaissance investigations and to utilize full State participation. We will continue to work with the State Planning Office, the Department of Economic and Community Development and the other resource agencies as required.

If you have any further questions regarding the reconnaissance investigations to be performed in Maine, I can be reached at (617)647-8522

Sincerely,

Thomas A. Rhen
Colonel, Corps of Engineers
Division Engineer

Copies Furnished:

Mr. Nathaniel Bowditch, Director
Maine Department of Economic &
Community Development
State House Station #59
Augusta, Maine 04333

Mr. Richard H. Silkman, Director
Maine State Planning Office
State House Station #38
Augusta, Maine 04333

Ms. Katrina Van Dusen
Maine State Planning Office
State House Station #38
Augusta, Maine 04333

Mr. Tom Marcotte
Maine Department of Economic
& Community Development
State House Station #130
Augusta, Maine 04333